3

Operation

This chapter briefly summarizes the cardiograph's operation. This information is intended for the service person and is not a substitute for the information in the operator's manuals. Refer to one of these manuals for more comprehensive and detailed operating instructions.

- *PageWriter XLi Operating Guide*
- *PageWriter XLi Cardiograph User's Reference*
- *PageWriter XLi Cardiograph Physician's Guide*
- *PageWriter XLs User's Guide*
- *PageWriter XLe User's Guide*

Note

Refer to the appendixes for information on using the SAECG application, the fax modem, and the VCG application. Refer to the end of this chapter for information on using Preview Plus.

The Keyboard and Front Panel

Figure 3-1 shows the keyboard and front panel. Controls and indicators shown are described on the following page.

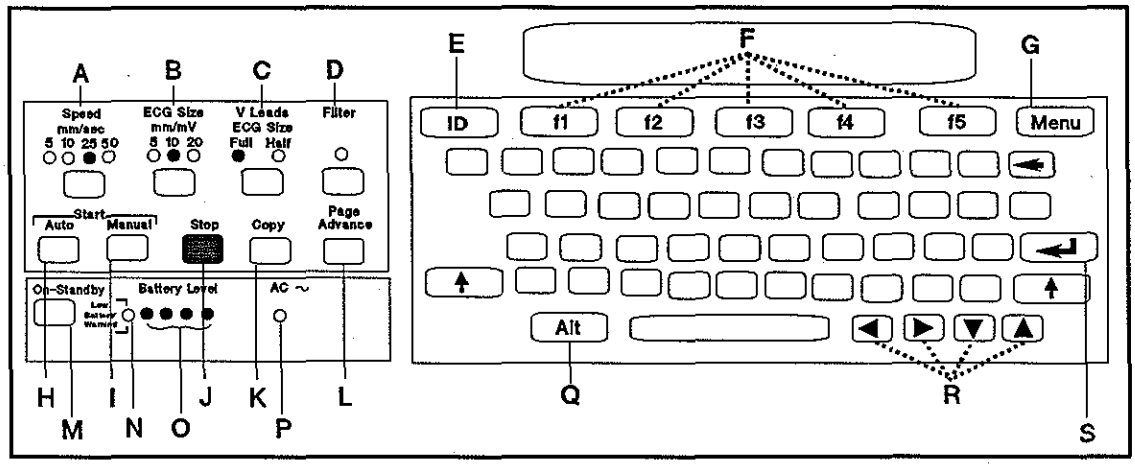


Figure 3-1. The Keyboard and Front Panel.

A	Speed	Changes the paper speed. It switches between 5, 10, 25, and 50 mm/sec for Manual ECGs, and between 25 and 50 mm/sec for Auto ECGs.
B	ECG Size	Changes the limb and chest lead sensitivity between 5, 10, and 20 mm/mV.
C	V Leads	Changes the chest lead sensitivity between full and half size with respect to the value set by the ECG Size key.
D	Filter	Turns artifact and baseline wander filters on and off depending on which filter or filters are set in configuration.
E	ID	Allows patient identification entry, review, and edit.
F	softkeys	These five keys (f1 - f5), called "softkeys," appear directly beneath the display window and perform different functions at different times. When a particular f key is active, a label describing its function appears above it in the display window.
G	Menu	Changes the softkey selection between two displays.
H	Auto	Starts an Auto ECG recording.
I	Manual	Starts a Manual ECG recording.
J	Stop	Halts any cardiograph function.
K	Copy	Prints a copy of an ECG which has just been acquired.
L	Page Advance	Advances the paper to the beginning of the next page.
M	On-Standby	Switches the cardiograph between **On** and **Standby**. The cardiograph is not operational when in standby, but it is powered.
N	**Low Battery**	Light indicates that the cardiograph must be plugged in and recharged.
O	**Battery Level**	Lights indicate the remaining capacity level of the battery. When the battery is fully charged, all the lights are on. **Always check the battery level lights before disconnecting AC power.**
P	**AC** ∿	Light will be on when the power cord is plugged into a wall outlet and the AC switch is on. This indicates that the battery is charging. The AC switch is on the back of the cardiograph.
Q	Alt	Pressed with x at power on for cardiograph self-test.
R	◀ ▶ ▼ ▲	The left and right arrows move the cursor when typing information in data entry fields on the keyboard display. The down and up arrows select leads on Preview Screen.
S	↵	The Enter key.

Other Operating Controls

There are other operating controls that are not part of the keyboard. The knobs that control preview screen contrast and brightness are on the preview screen front panel (M1700A only). The remote start button, ◇, is located on the patient module (M1700A & M1701A only). The contrast controls for the keyboard display (above the keyboard) and the patient module display are key combinations entered at the keyboard.

Note

The M1702A patient module does not have a display or a remote start button.

To increase contrast on the keyboard display, press Shift and ▲; to decrease contrast, press the Shift and ▼. To increase contrast on the patient module display, press Alt and ▲; to decrease contrast, press Alt and ▼. You may need to press the arrow keys multiple times to achieve the contrast desired.

Choosing a Report Format

You can record two types of ECGs:

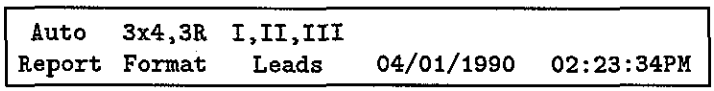
- Auto ECGs are 1-page, 12-lead ECGs with or without rhythm strips.
- Manual ECGs are continuous tracings of 3, 6, or 12 leads.

In addition, if you have the M1754A SAECG option you can record signal-averaged ECGs. Examples of a few of the ECG types are shown in the figures on the following pages.

To choose a report format, use the softkeys shown in the menu display below. This menu also allows you to set the date and the time (the procedure for setting date and time is described in Chapter 2). If you do not have this or a similar menu in the display, press Menu or Stop until you do.

Note

The information displayed in the message line (upper line of the display) depends on the format last chosen. For this reason, your display may be different than the example shown here.



Report Selects between the Auto or Manual report menus.

Format Selects the number of leads and the report presentation. The selections are:

Auto Formats	Manual Formats
3×4, 3R	6
6×2	12
3×4	3
3×4, 1R	

Note

The Auto Formats are in "row by column" format. "R" means rhythm strips.

Leads

For an Auto report (3×4, 3R and 3×4, 1R only), this key selects the set of leads used for rhythm strips. For a single rhythm strip (1R) you select any one of the twelve leads; the default lead is I. For three rhythm strips (3R), the lead sets available are:

- **I, II, III**
- aVR, aVL, aVF
- V1, V2, V3
- V4, V5, V6
- Custom (Default = I,aVF,V2)

For a 3- or 6-lead Manual report, this key selects the set of leads used (12-lead reports automatically use all 12 leads). The selections for the 3-lead set are the same as for the 3R sets listed above. The selections for 6-lead sets are:

- **I, II, III, aVR, aVL, aVF**
- V1, V2, V3, V4, V5, V6
- Custom (Default = II,aVF,V1,V2,V4,V6)

Note

You can change power-on default leads in Global Configuration.

The lead selections listed above are for the Standard configuration. If the cardiograph is configured for Cabrera leads, the lead selections that appear will be different. Also, if pediatric, Frank, or research leads are connected in place of standard leads, the cardiograph detects their presence and alters the displayed lead sets accordingly.

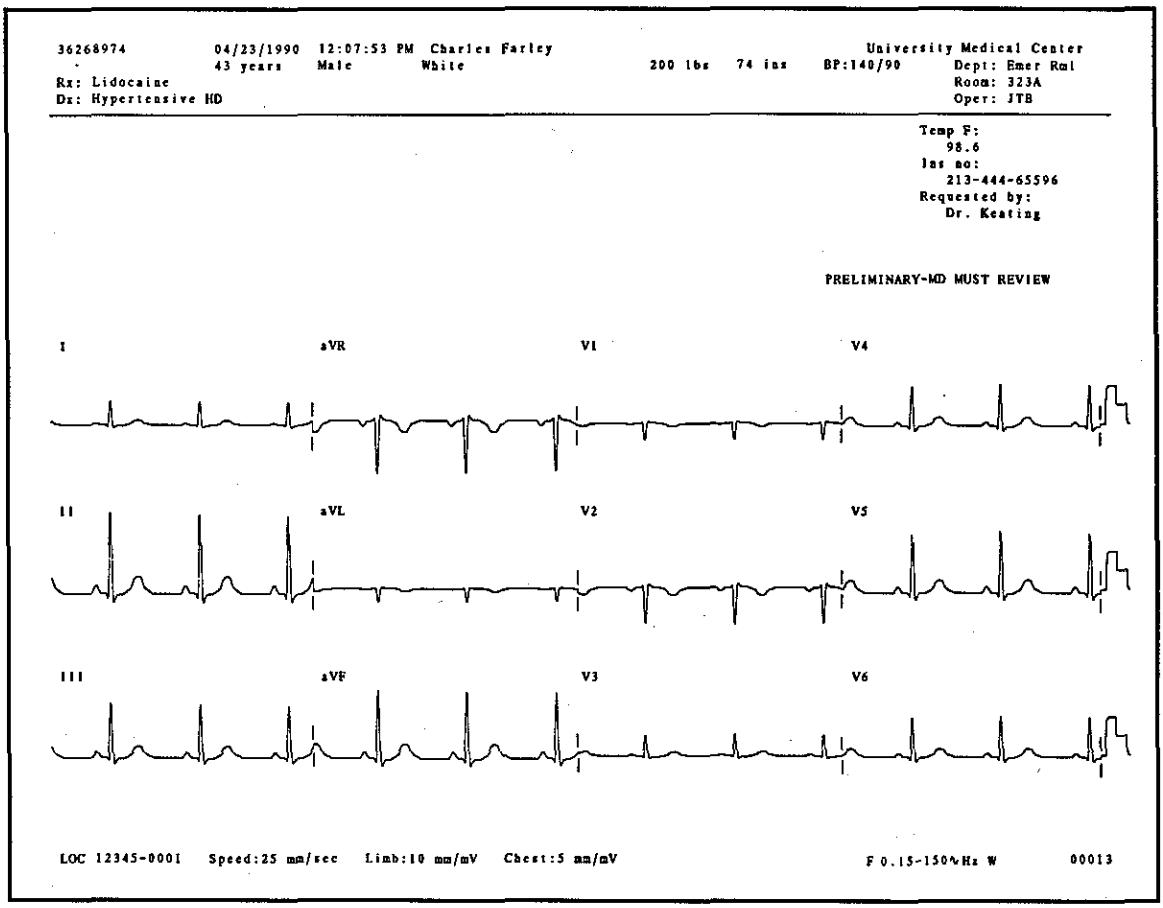


Figure 3-2. An Auto 3×4 ECG (3×4).

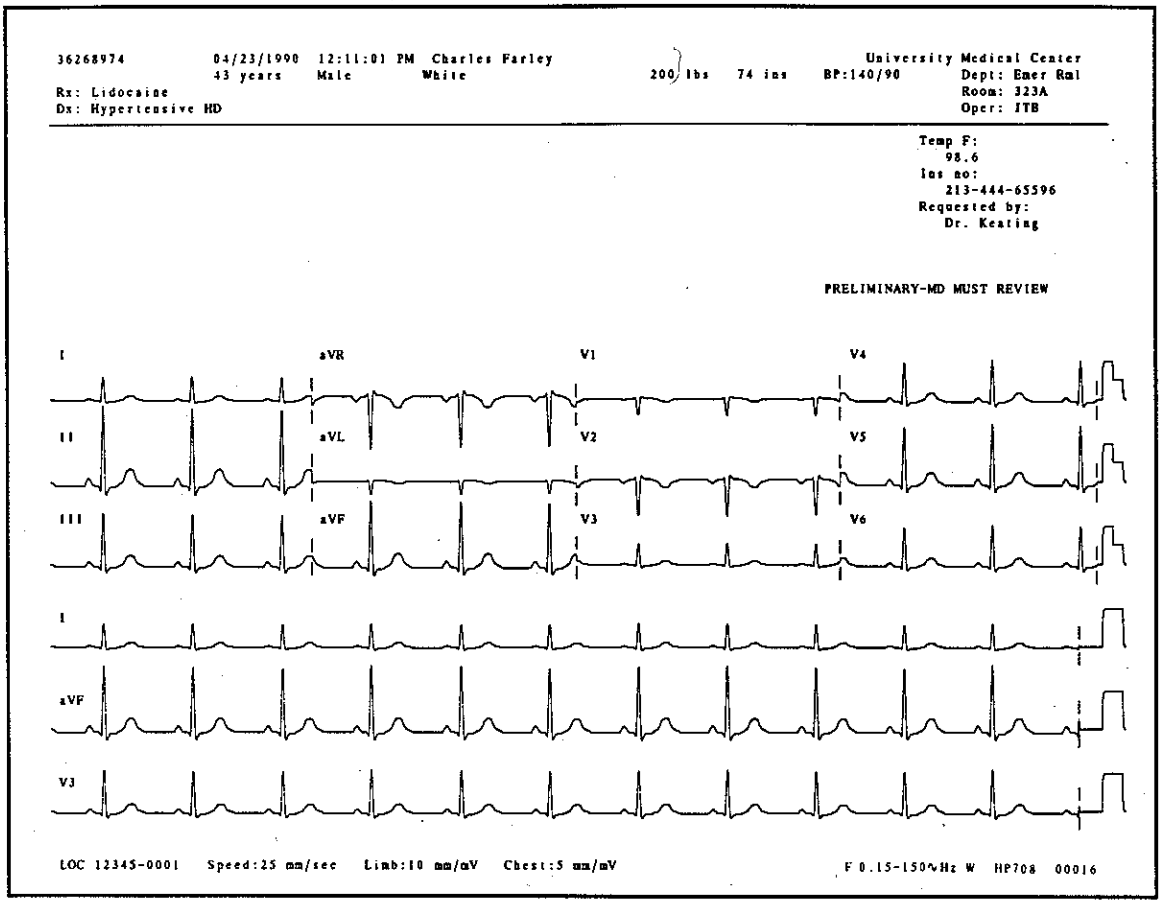


Figure 3-3. An Auto 3×4 ECG With Three Rhythm Strips (3×4, 3R).

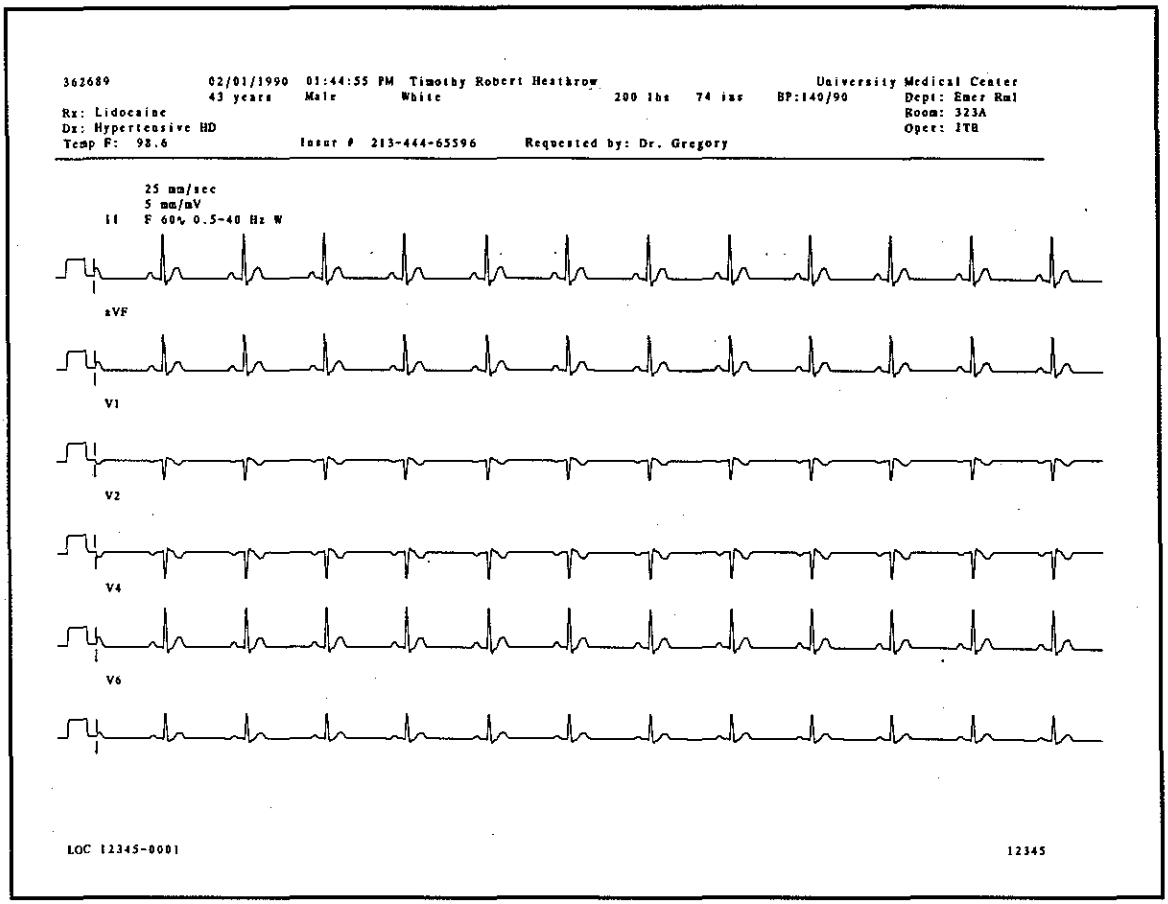


Figure 3-4. A Manual 6-Lead ECG.

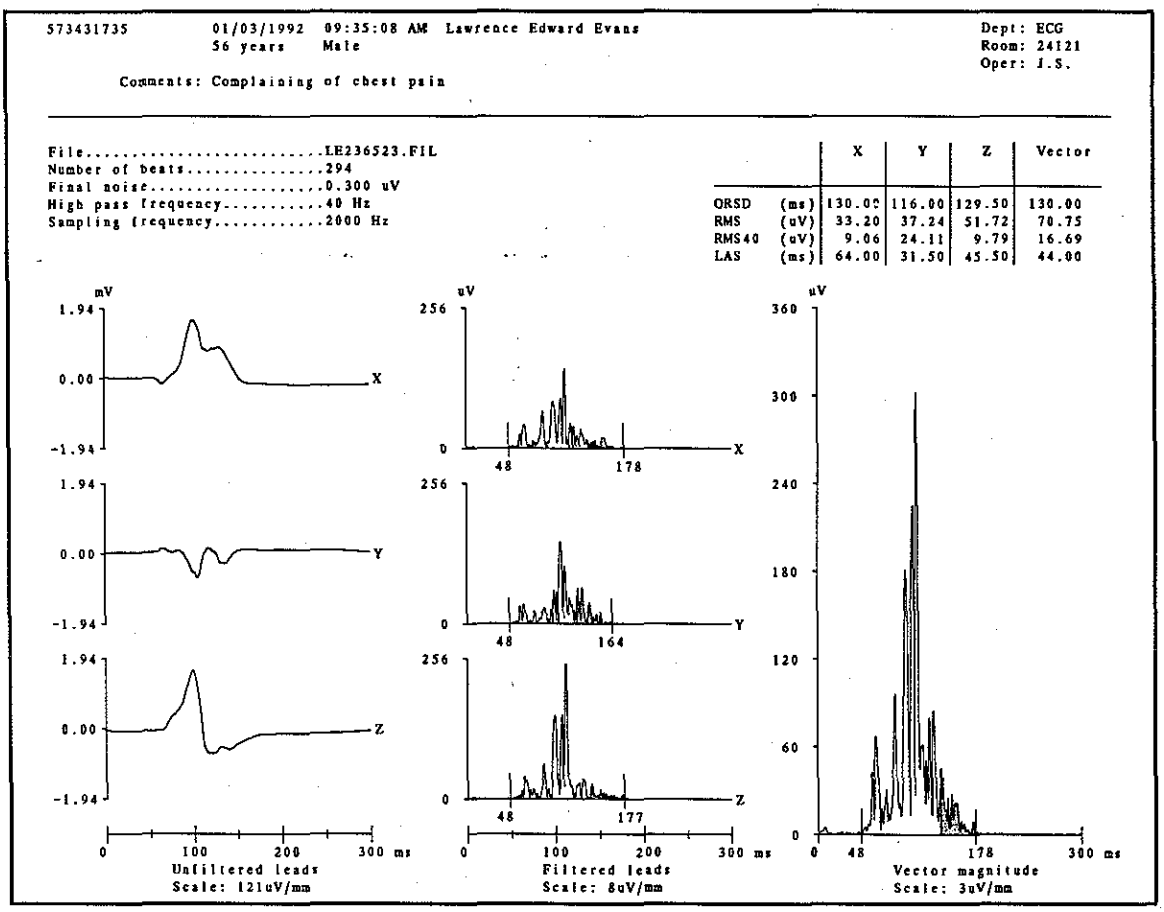


Figure 3-5. An SAECG Report.

Main Functions

This section discusses the cardiograph features and functions that you access from the alternate main menu selected by the Menu key.

Note

If you have the A.02.00 software, these functions appear in the XLi application.

To begin, press Menu until the following display appears:

```
Transmit   Store   Config   CheckDisk   Files
```

`Transmit`	Selects stored ECGs for transmission to another site.
`Store`	Stores the last recorded Auto ECG on disk.
`Config`	Provides access to the cardiograph's operating parameters. Refer to Chapter 2.
`CheckDisk`	Checks the disk and reports how much storage capacity is in use.
`Files`	Provides access to the stored files for ID editing, printing, analyzing (M1700A only), or deleting.

These functions are described in the following pages.

Note

The `Transmit` softkey appears only on the M1700A.

Note

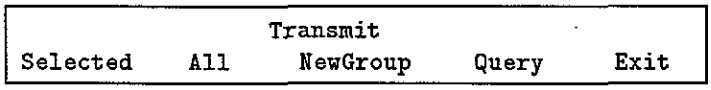
The M1702A Menu key brings up the following menu:

```
                Configuration
Global      ID                  Print      Exit
```

`Global`	Provides access to the cardiograph's operating parameters. Refer to Chapter 2.
`ID`	Provides access to the cardiograph's operating parameters. Refer to Chapter 2.
`Print`	Prints the cardiograph configuration.
`Exit`	Returns to the main menu.

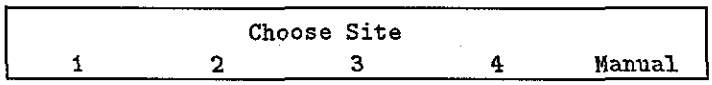
Transmit (M1700A Only)

When you press `Transmit` the following menu is displayed:



`Selected` Presents the selection display (the selection display is described at the end of this section). Allows you to select one or more stored ECGs for transmission. If AutoDial is enabled, the cardiograph automatically dials and transmits the selected ECG(s) to the chosen site when you press `Transmit` in the selection display.

`All` Transmits all the stored ECGs. If AutoDial is enabled, the cardiograph dials and transmits immediately. If AutoDial is not enabled, the following display appears:



Selecting one of the numbers initiates transmitting to the site assigned to that number. If you select Manual, the display prompts you to enter configuration information. Refer to Chapter 2 for details about configuring autodial sites.

`NewGroup` Transmits only those ECGs that have not previously been transmitted.

`Query` Calls a site to receive ECG information. Query is used only with an ECG management system. The PageWriter can receive ECGs from an ECG management system on request by using the Query function. PageWriters with A.01.XX software can only receive text information this way, and cannot receive ECG traces.

Note

The PageWriter provides two types of Query: standard and interactive (interactive query is only available with A.02.XX software).

In standard query text reports (analysis only) are queued at the system for output to the cardiograph. Only diagnostic and extended measurement reports can be sent in standard query.

In interactive query, the cardiograph user selects the ECG to receive. A single patient's ECG (report and waveform) can be retrieved from the system this way by answering yes to the question `Select an on-line report`.

Note

Revision A.02.XX software enables the M1700A to transmit Auto 6×2 ECGs to the F.A.A. ECG management system.

`Exit` Returns you to the previous menu.

Store (M1700A & M1701A only)

This key stores the current Auto ECG on the disk (Manual ECGs cannot be stored). An ECG must have a patient ID number before it can be stored. If the ECG to be stored has no patient ID when you attempt to store it, the cardiograph asks if you want to give it one. If your answer is "No," the cardiograph aborts the store attempt and returns you to the alternate main menu. If your answer is "Yes," the cardiograph takes you through the patient ID entry process as if you pressed the (ID) key on the front panel.

Once you enter a patient ID and exit the patient ID entry process, the cardiograph stores the ECG on the disk. The message `Storing ECG` appears while the ECG is being stored. Then the display returns to the main menu.

If the disk you inserted in the drive is new and unformatted, the cardiograph will ask if you want the disk formatted. Press `Yes` if you do (formatting takes about 90 seconds), or insert a formatted disk in the drive at this time. A disk must be formatted for storage to take place.

Note

The A.02.XX software allows you to erase (reformat) flexible disks by using `CheckDisk` (see below).

Config

This function allows you to configure the PageWriter. See Chapter 2 for details.

CheckDisk (M1700A & M1701A only)

A.01.XX Software

With the A.01.XX software, CheckDisk allows you to determine how much storage capacity remains on the disk. When you press `CheckDisk`, a message similar to the following appears in the display:

```
Disk 25% full
```

A.02.XX Software

The A.02.XX software enables CheckDisk to reformat flexible disks as well as determine how much storage space is available on the disk.

When you press CheckDisk, the message Reading the disk ... appears, followed by a second message that shows the percentage of storage space available on the flexible disk. For example, you may see a message such as:

```
Disk 25% full.
        Erase                Exit
```

If you want to reformat the disk, press Erase.

Files (M1700A & M1701A only)

This key gives you access to several functions that allow you to manipulate the stored ECGs in a variety of ways. When you press this key, this menu appears:

```
Delete    Log    Edit    Print    Analyze
```

Delete Allows you to delete stored ECGs. This key brings up the selection display (the selection display is described at the end of this section). After you select the patient ID numbers for the ECGs that you want to delete, press the Delete softkey in the selection display. The cardiograph displays the question Start Deleting 1 ECG(s)? (The number "1" will vary in all messages depending on how many ECGs were selected.) Press Yes if you want to continue. The message Deleting 1 of 1 ECG(s) appears and the ECG is removed from the disk. The following display appears to confirm that the ECG is deleted. Press Exit to continue.

```
1 ECG(s) deleted
                                    Exit
```

Log Prints the ECG-Log or Store-Log. The cardiograph prompts you to select before printing.

The ECG-Log is a list of the last 60 Auto and Manual ECGs recorded on the cardiograph. It shows the time and date the ECGs were recorded and if they were stored. The Store-Log lists all Auto ECGs stored on the flexible disk currently in the disk drive. It shows if ECGs on the disk were transmitted, analyzed, or edited.

`Edit` Enables you to edit the patient ID information on stored ECGs when you press the `Edit` key on the selection display. The cardiograph displays the patient ID information for editing just as it does when you press the (ID) key on the front panel.

When you finish editing, the cardiograph offers to store the ECG on the disk. When the storage is complete or if you press `No`, the alternate main menu returns to the display.

Note

On the M1700A only: when you finish editing, the cardiograph offers to analyze the ECG again. When this analysis is complete (or if you decline analysis), *then* the cardiograph offers to store the ECG.

`Print` Prints the selected ECG(s) when you press `Print` on the selection display menu (the selection display menu is described at the end of this section). While the ECG is printing this message is displayed:

```
Printing 1 of 1 ECG(s).
```

When the printout is done, this message is displayed:

```
Printed 1 ECG(s).
```

`Analyze` **This function is available only on the M1700A.** Analyzes the selected ECGs when you press `Analyze` on the selection display menu. Also provides the option of printing the analyzed ECG(s). While the cardiograph analyzes the ECG(s), these messages appear:

```
Reading 1 of 1 ECG(s).
Analyzing 1 of 1 ECG(s).
Storing 1 of 1 ECG(s).
```

When complete, the cardiograph displays

```
Analyzed 1 ECG(s).
```

Choose `Exit` to return to the alternate main menu.

The Selection Display (M1700A & M1701A only)

The selection display is a two-part menu that allows you to select patient ID numbers of stored ECGs for operations such as transmitting, editing, deleting, printing, and analyzing.

Selection Display Menu, Part 1

The first part is a display similar to the menu shown here.

```
123456                                  04-01-90   11:25:51AM
Select   Function    Next    Previous      More
```

Select — Selects the patient ID number displayed in the message line. An asterisk (*) appears before the entry to indicate its selection. If the number is already selected, pressing this key de-selects the number. As you move through the list of stored ECGs, you can select any number of ECGs (except in the edit function, which allows only one selection).

Function — Starts the function for which you are selecting an ECG. This key has one of the following function names:

- Transmit (appears only on the M1700A)
- Delete
- Analyze (appears only on the M1700A)
- Edit (allows only a single ECG selection)
- Print

Next — Steps forward through the list of stored ECGs.

Previous — Steps backward through the list of stored ECGs.

More — Displays the second part of the selection display menu, shown in the next section.

Selection Display Menu, Part 2

The second part of the selection display menu is similar to this one.

```
123456                                  04-01-90   11:25:51AM
          Function      All      Find       More
```

Function — The function label appears in both menu parts for convenience. You can initiate the function without toggling to the other part of the menu.

All — Selects all stored ECGs. (Not available with **Edit**.)

Find — Selects a specific ECG—you enter the number.

More — Switches to the first part of the menu.

Recording an ECG

To record an Auto ECG:

1. Press (Auto) on the front panel.

Note

Your cardiograph may be configured to automatically request patient ID each time you start an ECG. To override the request for patient ID, press (Auto) again.

- If you entered the current patient's ID before you pushed the (Auto) key, the ECG will be recorded without further prompts.
- If you have **not** recorded an ECG since turning on the cardiograph, the message `No ID# entered. Continue?` will appear. Press `Yes` to record the ECG without ID. Press `No` to start entering patient ID.
- If you have recorded an ECG since the cardiograph was turned on, the question `Continue using ID#?` appears.
  Press `Yes` if you have entered a patient identification number and want to take more ECGs from the same patient.
  Press `No` if you are recording an ECG from another patient.

2. The status messages `Acquiring ECG`, a signal quality message (M1700A only), and `Printing Auto Report` appear. If you have not yet entered the patient ID yet and AutoStore has been turned on during configuration, the message `ID required to store. Store ECG?` appears. Pressing `Yes` takes you through ID entry before storing the ECG; pressing `No` aborts the storage.

Note

ECG interpretation is a feature of the M1700A only, and depending on the configuration, electronic interpretive information may be prevented from appearing on the printed copy. Refer to the configuration information in Chapter 2 (see Initial, Copy, and Print Interpretation).

To record a Manual ECG, press (Manual) on the front panel. The status message `Printing Manual Report` appears. The cardiograph will print the ECG continuously until you press the (Stop) key or the ◇ on the patient module.

You cannot store a Manual report.

Note

Your cardiograph may be configured to request patient ID automatically each time you start an ECG. To override the request for patient ID, press (Manual) again.

`Reformat`	Reformats a stored 500 sample/second ECG for printing using a format and features you select. To reformat a stored ECG, insert the ECG storage disk in the cardiograph and press `Reformat`. A selection display appears, and you can select an ECG to reformat. Once you select the ECG, a screen appears that allows you to select the format and features you want. Press `Print` to print the reformatted ECG. You cannot store a reformatted ECG. It will be stored in the format in which it was originally recorded.
`Timed`	Enables you to record an ECG automatically at regular intervals. To do this, press `Timed`. The message `Interval in minutes? (1 - 20)` appears. Enter the interval at which you wish the cardiograph to record Auto ECGs, then press `Enter`. Press (Alt) and (F2) to begin the series of Auto ECGs. An ECG will be recorded immediately and at each interval thereafter. Press (Stop) when you want to stop recording ECGs.
`ContPrev`	Lets you monitor a patient's ECG continuously on the preview screen, even when printing an ECG. To turn on the Continuous Preview application, press `ContPrev`. The message `Continuous Preview On?` appears. Press `Yes`. To turn off Continuous Preview, press `ContPrev` again. When the message `Continuous Preview On?` appears, press `No`.
`Delayed`	Prints ECG information six seconds after the PageWriter receives it. This allows you to capture waveform information currently displayed on the preview screen. To set your cardiograph for recording a delayed Manual ECG, press `Delayed`. The message `6-Second Delayed Manual?` appears. Press `Yes` and the cardiograph will begin to save ECG information. When you see an ECG sample that you wish to print, press (Manual). Press (Stop) to stop the printing. To return to non-delayed ECG mode, press `Delayed` again. When the message `6-Second Delay Manual?` appears, press `No`.

Note

You can also configure the PageWriter to use Preview PLUS as its Power-On application. See "Power-On Application" in Chapter 2 for more information.

4

Performance Verification and Maintenance

Introduction

This chapter describes how you verify the cardiograph's performance, explains preventive maintenance, presents patient safety information, and provides a performance verification checklist.

Performance Verification

Three procedures make up performance verification: visual inspection of the cardiograph exterior, execution of Extended Self-test, and visual examination of an ECG recorded from an ECG patient simulator.

The performance verification checklist at the end of this chapter summarizes the steps you should follow to verify the cardiograph's performance. These are some suggested uses for this checklist:

- Make copies of the blank checklist, then fill out a copy each time the cardiograph is tested.
- Attach the printer test output, simulator ECG trace, and error log printout to the completed checklist and file with the cardiograph's permanent maintenance record.

Visual Inspection

Before beginning the inspection, press the On-Standby key to put the cardiograph in **Standby**, and unplug the power cord from the wall outlet. Then inspect the cardiograph for the following:

- Worn or damaged power cord
- Loose or missing hardware
- Mechanical damage
- Evidence of liquid spill
- Worn printer drive gear
- Worn printer roller
- Corroded or damaged electrodes
- Worn or damaged patient module cable
- Dirt on the thermal printhead

Replace any damaged or missing items, and clean the printhead and patient electrodes as necessary. Cleaning instructions are listed under "Preventive Maintenance" later in this chapter. Connect the cardiograph to AC power and turn on the AC switch. Observe that the AC indicator comes on. Turn the cardiograph **On** and observe that one or more of the battery indicators light.

Extended Self-test

The cardiograph's Extended Self-test, loaded as part of the system software, tests each major subassembly. The display tests and the printer test require visual verification of displayed or printed output.

In most cases, a test failure halts the test and a message indicating the failure appears on the keyboard display. In the case of the tests that require visual verification, visible failure symptoms appear in the printed or displayed test pattern. See Chapter 6, "Troubleshooting," for a list of self-test failure messages and failure symptoms.

To begin the Extended Self-test, press (On-Standby) to turn on the cardiograph, then quickly press and release the (Alt) and (x) keys simultaneously. The following display will appear:

```
Test: All
  Select     Test      Next     Previous  ErrorLog
```

The upper line displays the test choice, while the lower line displays the softkey labels. With the softkeys you step through the test menu, select tests, and initiate testing.

`Select`	Selects the test displayed in the message line. Asterisks (*) appear around the test name to indicate its selection. If the test is already selected, pressing this key de-selects the test (the asterisks disappear). You can select one or more tests in any combination, but the sequence is fixed.
`Test`	Begins running the selected test(s).
`Next`	Steps forward through the test menu.
`Previous`	Steps backward through the test menu.
`ErrorLog`	Prints out the stored error log.

To stop or exit Extended Self-test, you must press (On-Standby) to place the cardiograph in **Standby**.

These are the tests available in Extended Self-test:

- Patient module and cable
- CPU assembly
- Printer
- Disk drive (M1700A and M1701A only)
- Preview display (M1700A only)
- Keyboard display
- Modem and cable (M1700A only)
- All

Each test in this list is described in more detail in the discussions that follow.

To begin running the tests you press Test. The test or tests that you selected then run continuously until you stop the Extended Self-test. After each successful pass through the tests, the number in the message `Selected tests passed` *nnnn* `times.` increases by one. To stop the Extended Self-test, you must place the cardiograph in **Standby**.

Patient Module and Cable Test

This test looks for failures in the patient module and patient data cable, and generates a test pattern in the patient module display.

If the patient module fails the test, the message `Patient module test failed.` appears on the keyboard display. If the cable fails the test, the message `Patient module cable test failed.` appears.

Note

The patient module test does not test the patient electrodes or leadwires. Test the patient electrodes and leadwires by recording an ECG from a patient or ECG simulator as described later in this section.

Note

The M1702A patient module does not have a display.

The test patterns displayed on the patient module consist of (in this order):

- all white cells
- checkerboard cells
- all black cells
- inverse checkerboard cells
- 80 characters (displayed in 5 successive groups of 16)
- all white cells

You must observe the patient module display while the test pattern is running to ensure:

- accurate rendition of all patterns and characters
- no random lines or dots are displayed

Before and after the tests, asterisks appear in the display.

CPU Assembly Test

This test looks for failures in the following CPU assembly subsystems:

Real-time Clock
Printer Controller
Read-Only Memory (ROM)
Random Access Memory (RAM)
Digital Signal Processor (DSP)
DSP RAM

If the CPU assembly fails the test, the message `CPU assembly test failed.` appears on the keyboard display.

Note

The printer door must be closed to properly test the CPU assembly.

Printer Test

The printer test exercises the printhead and paper drive mechanism by printing a test pattern on the page four times, once for each printer speed. The pattern consists of a rectangular box that contains the entire character font, a column of numbers, and a black & white pattern. While the test patterns are printing, the message `Printing test pattern ...` appears in the keyboard display.

When the printout is complete, inspect it for:

- straight diagonal lines
- consistent print quality for all four patterns
- constant width for all four patterns
- visible separation between the close parallel lines
- accurate rendition of all characters
- clean black bars with no dropout in black areas
- perforation aligned with tear bar

If the printer assembly fails the test (not including the visual verification of the printout), the message `Printer test failed.` appears on the keyboard display.

Disk Drive Test (M1700A and M1701A only)

Caution

This test destroys any data previously recorded on the disk. Be sure that any data on the disk is expendable, or use a blank disk.

The disk drive test formats, writes to, and reads from a disk installed in the drive. When you select the disk drive test, the following display appears requesting confirmation of the selection:

```
Disk test destroys disk data. Select?
Yes                                  No
```

`Yes` Allows the test to be selected.

`No` Prevents the test from being selected.

Suggestion

Clearly label and set aside a test disk to help avoid the possibility of accidently destroying valuable data.

If the disk drive fails the test, the message `Disk drive test failed.` appears on the keyboard display.

Note The disk drive test will fail if the disk is write protected, or if the test is started when there is no disk in the drive.

Preview Display Test (M1700A Only)

The preview display test checks the preview logic board by writing data to and reading data from the board. This test also displays test patterns on the preview screen. Each of the following patterns appears on the screen for several seconds and in this order:

- checkerboard pattern
- inverse checkerboard pattern
- all black screen
- vertical white bar moving left to right
- horizontal white bar moving top to bottom
- all white screen
- horizontal black bar moving bottom to top
- vertical black bar moving right to left
- all black screen
- text characters in a white box on the black screen

The message `Displaying test pattern ...` appears on the keyboard display during the time the test pattern is on the preview screen.

You must observe the preview screen while the test pattern is running to ensure:

- accurate rendition of all characters and patterns
- no random lines or dots in the display
- no permanent patterns visible at normal contrast. Patterns may be visible at low contrast (darker screen); this is normal.
- no LCD flickering

If the preview display fails the test or if the test is run when a preview display is not installed on the M1700A, the message `Preview test failed.` appears on the keyboard display.

Note If the M1700A is not equipped with a preview display, selecting the preview display test results in a test failure. If you have selected the "All" test choice, remove the preview display test from the selected tests to avoid an erroneous test failure.

Keyboard Display Test

The keyboard display test exercises each cell in the LCD by displaying the following patterns:

- checkerboard cells
- all black cells
- inverse checkerboard cells
- all white cells
- text characters

You must observe the keyboard display while the test pattern is running to ensure:

- accurate rendition of all characters and patterns
- no random lines or dots in the display
- no permanent patterns visible at normal contrast. Patterns may be visible at low contrast (darker screen); this is normal.
- no LCD flickering

This test relies on the visual inspection of the test patterns for detecting failures. There is no failure message for the keyboard display test.

Modem Test (M1700A Only)

The modem test checks the operation of the Hayes® modem and its connecting cable.

Note

The cardiograph must be connected to AC power to operate the Hayes® modem.

If the modem passes the test, the message `Modem firmware checksum: xxx.` appears. If the modem fails the test, or if the test is run when a modem is not installed on the M1700A, the message `Modem test failed.` appears on the keyboard display.

Note

If the M1700A is not equipped with a modem, selecting the modem test results in a test failure. If you have selected the "All" test choice, remove the modem test from the selected tests to avoid an erroneous test failure.

All Tests

The "All" test choice allows you to select all the tests with one keystroke. Then when you press `Test`, Extended Self-test continuously runs all of the individual tests in sequence. At the end of each successful pass through the test sequence, the number in the message `Selected tests passed` *nnnn* `times.` is increased by one. If one of the selected tests fails, testing stops and the failure message for the failed test is displayed until the cardiograph is placed in **Standby** or shuts off due to a low battery.

Before you press `Test` to start the "All" selection, delete any tests that would cause a false failure indication. The tests that fall into this category are:

- the disk drive test (M1700A and M1701A only)—delete if you do not have a disk suitable for testing. Testing the disk drive with a write protected disk or without a disk installed will cause the test to fail.
- the preview display test (M1700A only)—delete if the M1700A does not have a preview display installed. The test will fail if a preview display is not installed.
- the modem test (M1700A only)—delete if the M1700A does not have a modem installed. The test will fail if a modem is not installed.

If you want to delete one or more of these tests after selecting "All," you can move through the list and press `Select` to remove any test from those selected. When you delete a test, the asterisks disappear from around the test name in the display.

Printing the Error Log

As errors occur, they are stored in memory in the error log. Pressing the `ErrorLog` softkey prints the stored error log. While the error log is printing, the message `Printing error log ...` appears on the keyboard display. When the printout is complete, you can select another test from the Extended Self-test menu.

To understand the error printout, refer to the error lists in Chapter 6, "Troubleshooting." Store the error log printout with the cardiograph's permanent maintenance record.

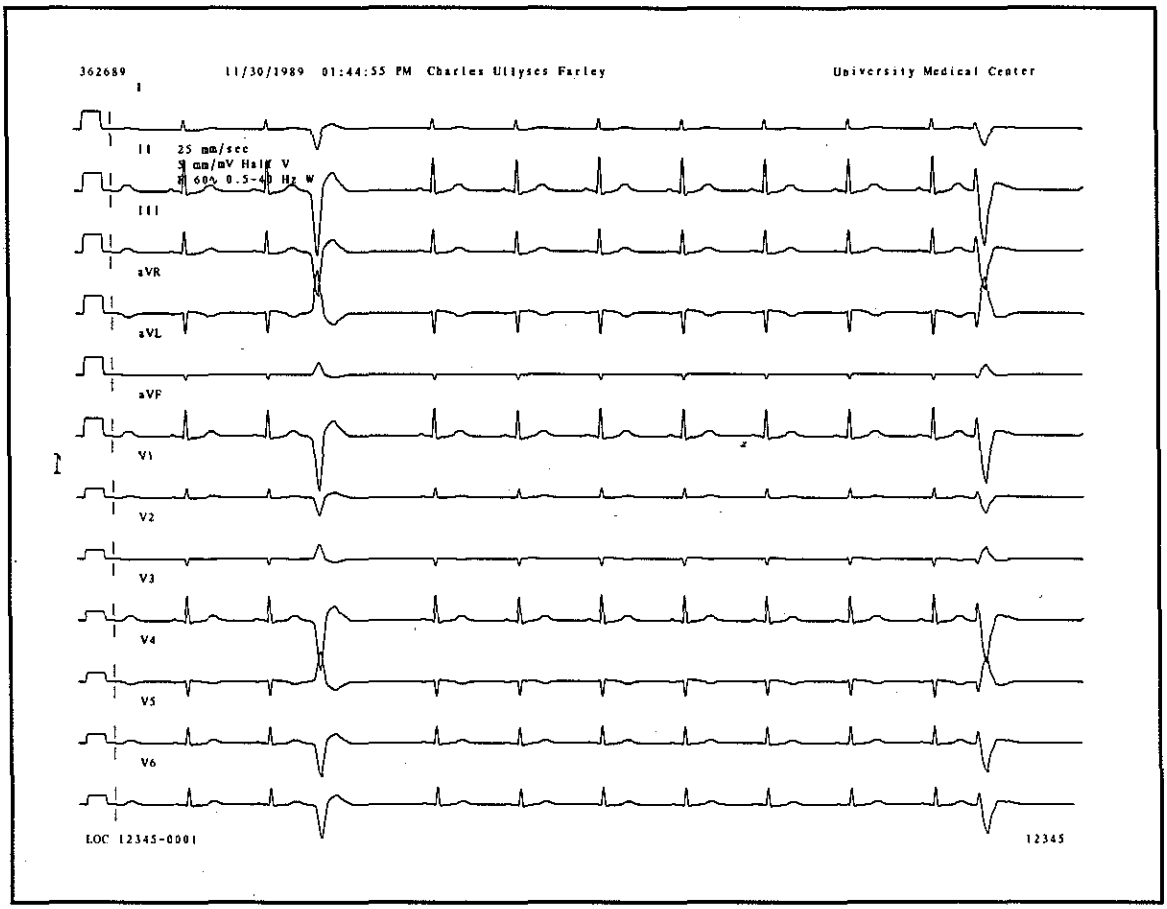


Figure 4-1. 12-Lead ECG from ECG Simulator.

ECG Simulation

Taking an ECG using a 12-lead ECG simulator allows you to verify areas of operation that Extended Self-test cannot test:

- the integrity of the patient module leadwires
- the accuracy of the paper speed
- the accuracy of the gain settings

The recorded ECG trace should look similar to the one shown in Figure 4-1, although there will probably be differences in the trace you record. The trace differences result from differences in simulators, simulator settings, and, more importantly, from differences in configuration and control settings on the cardiograph. To make a recording similar to the one in Figure 4-1:

1. Connect the patient module leadwires to the simulator. Check the display on the patient module to verify that all leadwires are connected and signal quality is adequate. Gently pull each leadwire taut and look for excessive noise on the patient module display.
2. On an M1700A with preview display, check that all twelve leads are displayed. The leads will be displayed in groups of three.

3. Select a Manual format on the front panel display (preferably 12 lead).

4. Press (Manual) on the cardiograph front panel (or press ◇ on the patient module) to start the recording.

When the recording is complete:

- Verify trace activity for all 12 leads. This assures integrity of all patient electrodes and leadwires. Noise should measure less than 1 mm, and there should be no baseline wander.
- Verify no gross distortion of complexes or calibration pulses (no overshoot, etc.).
- Verify that calibration pulses are of proper duration. This assures the correct paper speed. With the cardiograph set to record at 25 mm/sec, the calibration pulse should measure 5 mm (calibration pulse duration is 200 ms).
- Verify that calibration pulse amplitude is correct. This assures the correct gain. With the cardiograph gain set at 10 mm/mV, the calibration pulse should measure 10 mm (calibration pulse amplitude is 1 mV).

Note

An arrhythmia simulator is not an acceptable tool for verifying computerized ECG analysis. The analysis software is biased to process human ECG data.

Note

SAECG verification should not be required in addition to standard ECG simulation. However, you can use an ECG simulator to determine that the SAECG is functional. All leadwires should be connected to the simulator (though you do not need to connect specific leadwires to specific outputs). See Chapter 3 for more information.

Preventive Maintenance

Routine maintenance for the cardiograph consists mainly of cleaning and inspection.

Caution

The cardiograph does not require any kind of lubrication. Lubricating any part of the cardiograph could damage it or diminish its performance.

Care and Cleaning

The cardiograph and its accessories are chemically resistant to common cleaning solutions and non-caustic detergents. The following are some approved cleaning solutions for all of the outside surfaces of the cardiograph, the patient module, and the cart.

- Mild soap and water
- Chlorine Bleach (30ml/l water)
- 90% Isopropyl Alcohol

If the keyboard requires cleaning, you can remove it from the cardiograph and immerse it in lukewarm water.

Cleaning the Cardiograph and Patient Module

1. Unplug the power cord and ensure that the cardiograph is set to **Standby** at the front panel.
2. Wipe the external surfaces of the cardiograph, the patient module, and reusable electrodes with a soft cloth dampened in any of the approved cleaning solutions listed above. Avoid the leadwire inputs and cable connections.

Caution

Do not use any strong solvents or abrasive cleaning materials.

Do not spill any liquids on the surface of the cardiograph.

Do not immerse the patient module.

Do not use any of the following to clean the cardiograph:

- Ammonia-based cleaners
- Acetone
- Iodine-based cleaners
- Phenol-based cleaners
- Ethylene oxide sterilization (ETO)
- Autoclave

Cleaning the Keyboard

1. Carefully insert a small flat-bladed screwdriver into the notches at the top or bottom edge of the keyboard and pry the keyboard up.
2. Rinse off the keyboard and thoroughly dry it.
3. Snap it back into the cardiograph.

Caution

Do not wash the keyboard in hot water. Do not attempt to clean the keyboard in a dishwasher.

Cleaning the Printhead and Paper Sensor

If you use Hewlett-Packard recording paper, you should not have to clean the printhead for the life of the product. Should you decide to do so, this is the procedure to follow. These are the materials required:

- Foam swabs—Hewlett-Packard part number 9310-0468 or 9300-0767
- 90% Isopropyl Alcohol—Hewlett-Packard part number 8500-0559 or equivalent
- Dry, lint-free tissue—Kimwipes® or Hewlett-Packard lint-free wipes (Hewlett-Packard part number 92193W)

To clean the printhead:

1. From the front of the cardiograph, unlatch and open the paper door. The printhead is to the right under the paper blade, behind the ESD brush (see Figure 4-2).
2. Scrub the printhead with a foam swab moistened with isopropyl alcohol.
3. Dry the printhead with a lint-free tissue.

To clean the paper sensor lens:

1. From the front of the cardiograph, unlatch and open the paper door. The paper sensor lens is to the right under the printhead (see Figure 4-2).
2. Lightly wipe the paper dust off of the paper sensor lens with a dry foam swab.

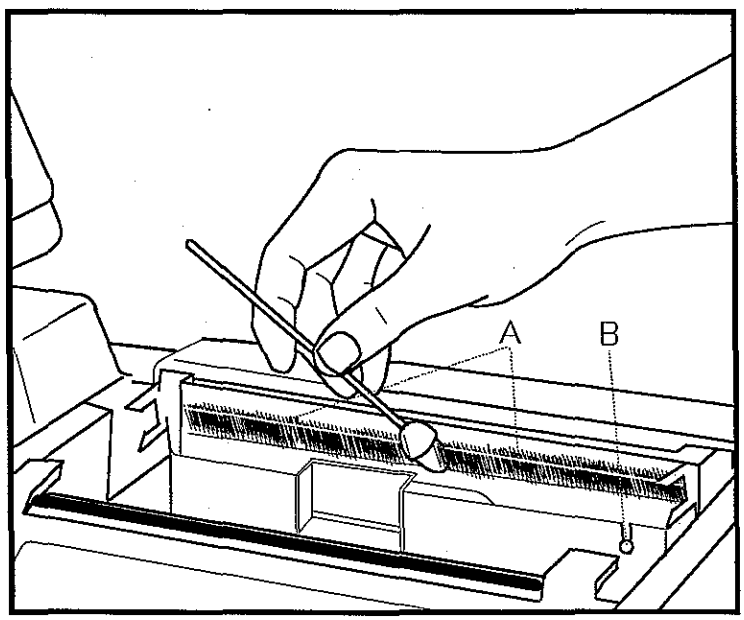


Figure 4-2. Cleaning the Digital Array Printhead.

A. Printhead
B. Paper Sensor

Maintaining the Flexible Disk Drive

Follow these rules to keep your flexible disks and their stored files in good condition.

- **Never** manually open the silver shutter on the disk.
- **Do not** expose the disk to direct sunlight, extremes of temperature or humidity, magnetic fields, or dust.
- Place the disk in a protective cover when the disk is not inside the drive.
- Store disks in a clean, dry place.
- Clean the disk drive with a wet-dry cleaning kit regularly. Wet-dry cleaning kits are available from local computer stores.

  Clean the disk drive every six months unless the working environment is particularly dusty or dirty. Clean the drive more often in dusty or dirty environments.

  TraceMaster ECG Management System users:

  If you transfer ECGs to the TraceMaster System by disk, clean the TraceMaster drive every six months unless the working environment is particularly dusty or dirty. Clean the drive more often in dusty or dirty environments.
- Replace disks regularly. The recommended replacement interval is every three months. If the disks are used for more than 50 ECGs per day, replace the disks more frequently.
- For best results, use only Hewlet-Packard recommended disks. (HP part number M1700-89004)
- For more information, contact your Hewlett-Packard service representative.

Cleaning the Electrodes, Leadwires, and Patient Data Cable

Clean the electrodes, leadwires, and patient data cable with a soft cloth moistened with soapy water. You also can use a disinfectant or cleaning agent such as Cetylcide®, Cidex®, Lysol®, Wescodyne®, or Ves-phene®. Wring any excess moisture from the cloth before cleaning.

Caution

- Do not autoclave cable or use ultrasonic cleaners.
- The leadwires and patient module cable are not immersible.
- Do not use abrasive materials to clean metal surfaces—scratches on electrodes cause artifacts.

Safety Tests

The safety tests listed below are performed at the time of manufacture to assure compliance with these standards: IEC 601-1, IEC 62D (CO)17, UL 544, and CSA 22.2 No. 125.

- Chassis-to-ground resistance
- Ground wire leakage current
- Enclosure leakage current
- Patient lead leakage current (source leakage) to ground
- Leakage current between patient leads
- Patient lead leakage current (sink current) with line voltage applied

Perform these tests as part of your preventive maintenance program, and after any corrective maintenance to assure compliance with the named standards.

To perform these tests, use a safety tester or analyzer designed specifically for this purpose. Follow the manufacturer's operating instructions.

PageWriter XL Performance Verification Checklist

Model number_____
Serial number_____
Test date_____
Test technician_____

Visual Inspection

Disconnect the cardiograph from AC power and inspect for the following:

- ☐ Loose or missing hardware
- ☐ Frayed or damaged wiring
- ☐ Mechanical damage
- ☐ Evidence of liquid spill
- ☐ Printer drive gear wear
- ☐ Printer roller wear
- ☐ Wear or damage to power cord and associated strain relief
- ☐ Corroded or damaged electrodes
- ☐ Damaged leadwires or patient module cable
- ☐ Dirt on the thermal printhead

Connect the cardiograph to AC power and turn on the AC switch. Verify the following:

- ☐ The AC indicator is lit.
- ☐ One or more green battery indicators are lit when (On-Standby) is pressed to turn on the cardiograph.

Extended Self-test

Run Extended Self-test, select "All" menu choice, and verify that each test passes with no errors.

- ☐ Patient module and cable
- ☐ CPU assembly
- ☐ Printer
- ☐ Disk drive (writable disk must be in drive, M1700A and M1701A only)
- ☐ Preview display (M1700A only—de-select test if not installed)
- ☐ Keyboard display
- ☐ Modem (M1700A only—de-select test if not installed)

Print out the error log. Store the printout with the cardiograph's permanent maintenance record.

ECG Simulation

Record an ECG using an ECG simulator. Verify the following:

- ☐ Trace activity for all 12 leads
- ☐ No gross distortion of complexes or calibration pulses
- ☐ Calibration pulses are of proper duration (200 ms) and amplitude (1 mV)

The trace will vary depending on simulator settings used and simulator type. Calibration pulse measurements will vary depending on the cardiograph gain and speed settings.

Comments:

5

Theory of Operation

This chapter contains an overview of the cardiograph operation, and circuit descriptions of the major subassemblies. Except as noted, the information in this chapter applies to the M1700A PageWriter XLi, the M1701A PageWriter XLs, and the M1702A PageWriter XLe.

Operational Overview

This overview covers two areas of cardiograph operation: the path that ECG data follows from collection to display, and the cardiograph's power-on/power-off sequence.

ECG Data Path

ECG data is collected at the patient module. There, the data from as many as 13 patient electrodes is sampled after the multiplexors at a 4 kHz rate. The cardiograph software determines the number of electrodes sampled and the order in which they are sampled. Following the multiplexors is the analog-to-digital converter (ADC). The ADC, by the process of successive approximation, converts the multiplexed analog signals to digital words. The patient module controller performs a parallel-to-serial conversion, then sends the data to the cardiograph. In the cardiograph, the digital signal processor (DSP) receives the ECG data, processes it, and sends it to the system RAM where it is stored.

The data stored in memory is then available for analysis (M1700A only), printing, display, or storage to disk (M1700A and M1701A only).

Power-on and Power-off Sequences

When the cardiograph is turned on or off, it follows a sequence of events in applying power to or removing power from its circuits. The gate array that controls dynamic RAM (DRAM) also controls this sequence because the DRAM gate array remains powered up even when the cardiograph is in **Standby**.

Power-on

When the (On-Standby) key is pressed to power up the cardiograph, the DRAM gate array asserts the processor reset signal and sends the UNITON signal to the +5 V regulator to turn it on. When +5 V is in regulation, the power supply signals the DRAM gate array, which releases the processor reset.

When the reset is released, the processor begins execution at its reset vector, FFFFF0h. This location is in ROM, which contains initialization routines and tables. The flow chart in Figure 5-1 shows the sequence that the CPU executes to initialize the cardiograph and begin cardiograph operation. Cardiograph operation begins after the CPU has begun executing the software stored in RAM.

Power-off

The power-off sequence is software controlled. The power-off sequence is initiated when the (On-Standby) key is pressed, battery timeout occurs, or the battery is too low to continue. At power-off, the software sees a keycode and begins housekeeping tasks such as completing disk I/O requests, turning off the printer, disabling the keyboard, turning off the keyboard display, and turning off the preview display if present. When the housekeeping is complete, the software instructs the DRAM and FGA gate arrays to stop the processor and shut down the power supply. The details of how the power supply shuts down are described later in this chapter in the power supply description.

Another method of shutting down the power supply is provided by the watchdog timer. The watchdog timer, part of the DRAM gate array, shuts down the power supply if the CPU is disrupted beyond recovery and fails to reset the timer before a specified time elapses. The timer is programmable and can be set by software for two, four, six, or eight seconds; the time depends on the operation currently being executed.

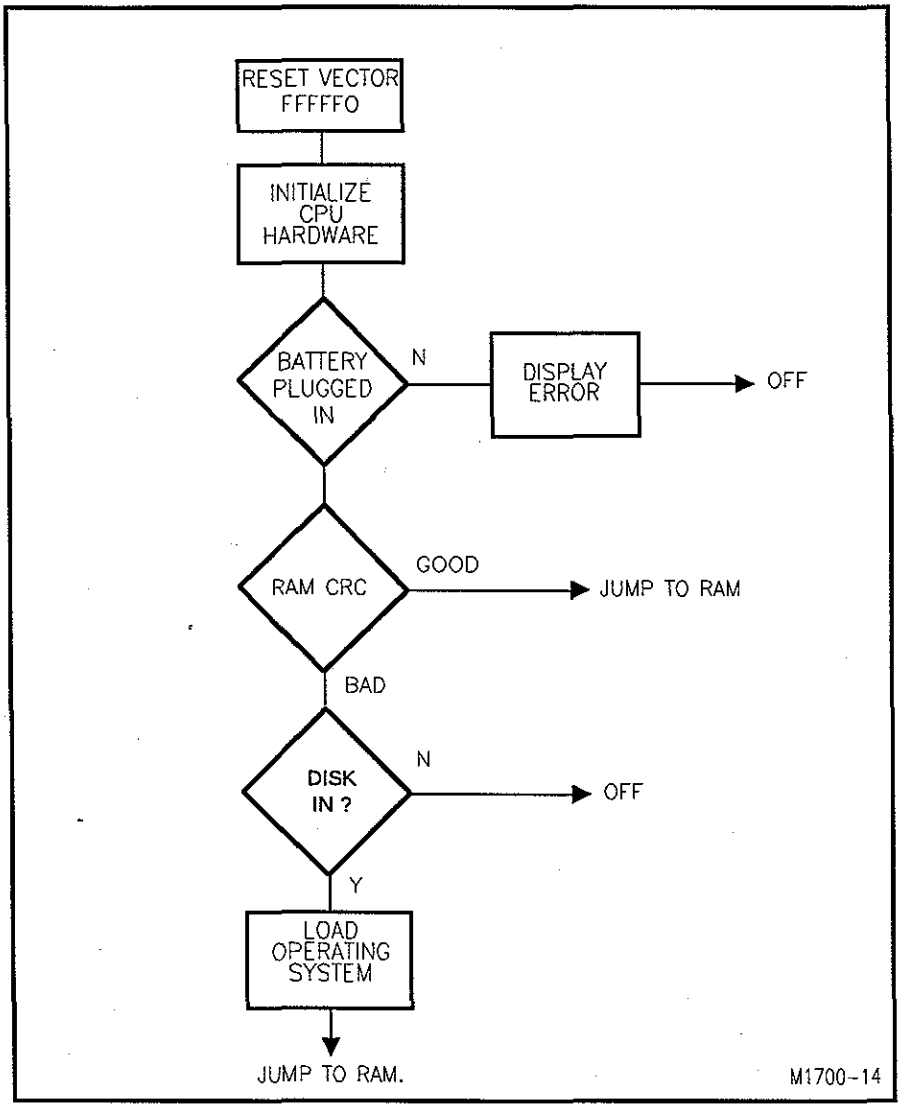


Figure 5-1. CPU Initialization Flow Chart.

Note

The M1702A cardiograph loads software from ROM, not disk.

Circuit Descriptions

The major subassemblies for both cardiograph models are the patient module, the CPU assembly (which includes the power supply), the keyboard and LCD display, the printer, and the disk drive (M1700A and M1701A only). The M1700A also has an optional display that the operator can use to preview the ECG.

The CPU assembly is the same for both cardiographs except that the M1700A CPU assembly has extra RAM to accommodate the ECG interpretation and analysis software. The M1701A and M1702A CPU Assemblies are identical, except for the ROM. The subassemblies, including the CPU assembly and its major circuit groups, are shown in Figure 5-2.

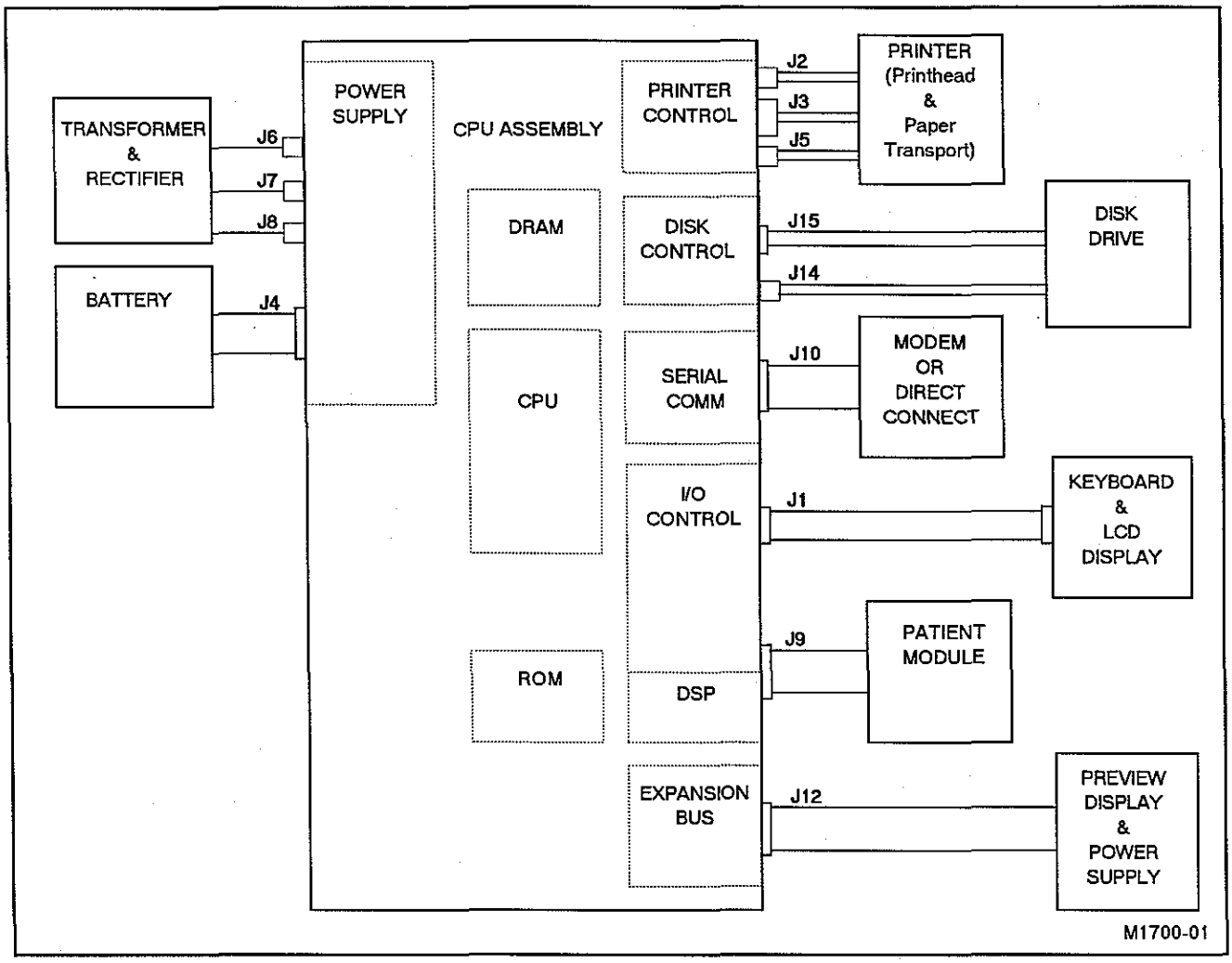


Figure 5-2. Simplified System Block Diagram.

Note M1702A does not have a disk drive.

The Standard Patient Module

The patient module collects data from up to 13 electrodes. The multiplexors sample the data and a calibration voltage at a 4 kHz rate, and a successive approximation analog-to-digital converter (ADC) digitizes the data. The patient module controller arranges the serial data from the ADC into 24-bit serial words that it sends to the cardiograph. The patient module electrically isolates the electrodes from the cardiograph with opto-isolators for the data and a transformer for the power.

The patient module receives leadwire status data from the cardiograph for presentation on the patient module's LCD display. A push button, ◇, on the patient module allows the cardiograph operator to remotely start a recording. Figure 5-3 is a simplified block diagram of the patient module's circuitry.

Note

PageWriter XLe, M1702A, does not have an LCD display or a push button.

The patient module connects to the cardiograph by a cable that plugs into the cardiograph at J9. The pin assignments for the patient module connector are described in Appendix A.

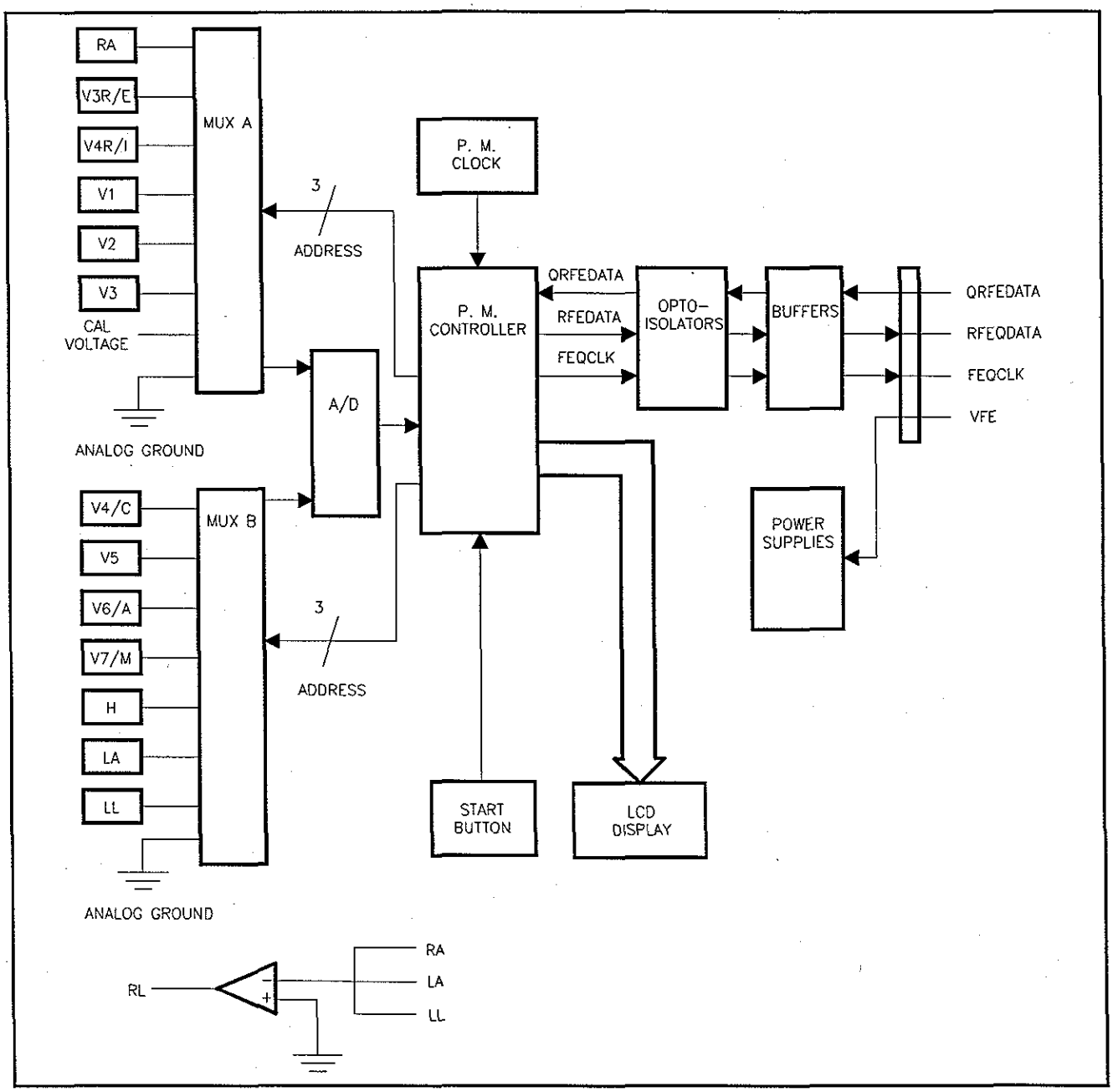


Figure 5-3. Patient Module Block Diagram.

CPU Assembly

This discussion of the CPU assembly covers the following circuits:

- CPU
- System Memory
- ROM
- I/O Control
- Digital Signal Processor
- Flexible Disk Drive (M1700A and M1701A only)
- System Expansion Connector

The block diagram in Figure 5-4 shows these circuits and how they interconnect.

CPU

The microprocessor used in the CPU is the Intel 80376®, a 32-bit processor with a 16-bit data bus and 24-bit address bus. The CPU address and data buses go to the DRAM block, the system expansion connector, and to latches and buffers, as shown in Figure 5-4. Address latches buffer the address signals in order to drive a larger number of devices and latch the addresses. Data buffers (transceivers) allow the CPU to communicate with a larger number of devices, and ensure that the CPU data bus is driven at the proper times. The programmable interrupt controller (PIC) accepts and prioritizes interrupt requests and generates the interrupt signal to the microprocessor.

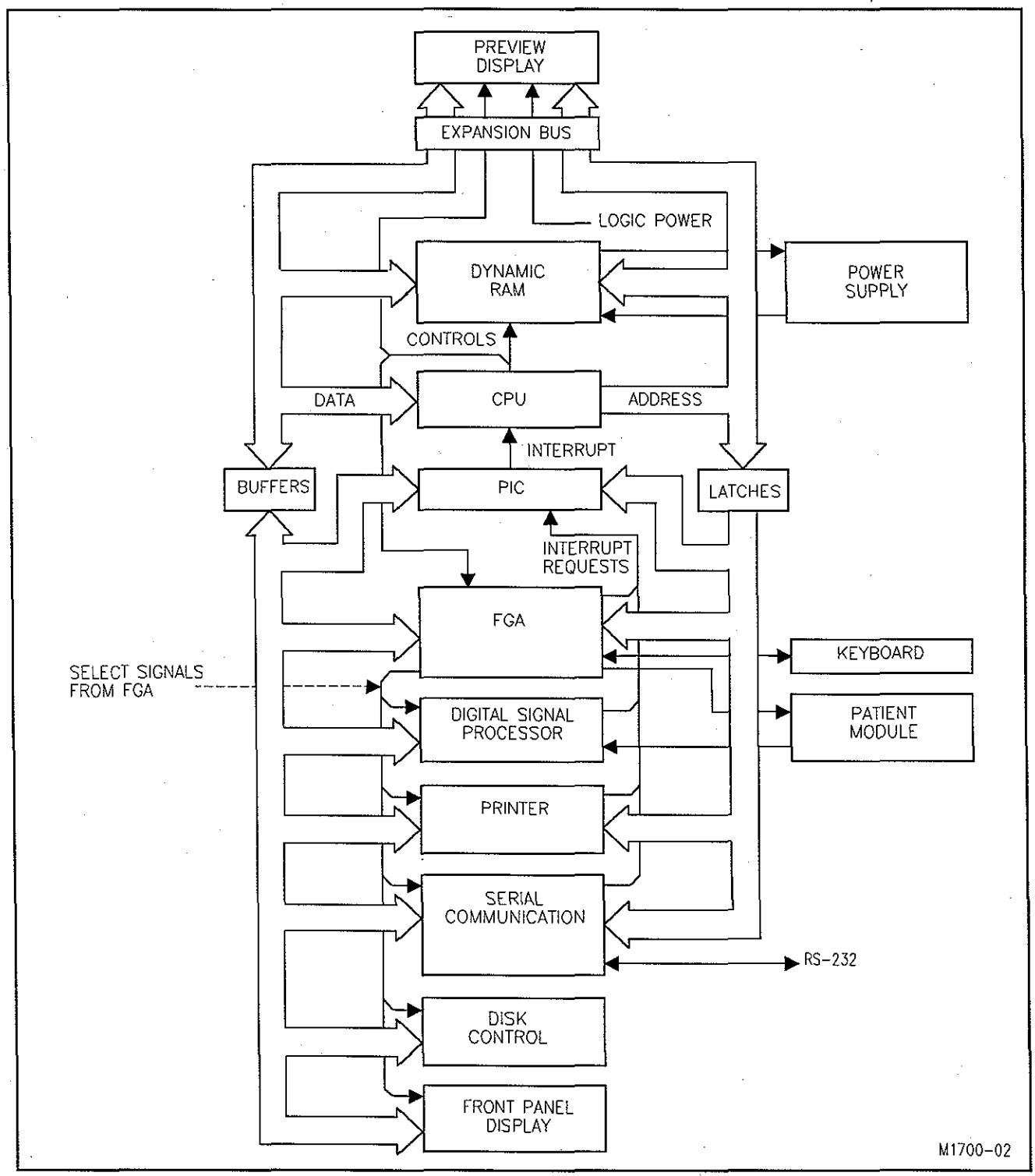


Figure 5-4. CPU Assembly Block Diagram.

System Memory

The system memory circuitry consists of the DRAM array, the DRAM gate array, and two data transceivers, as shown in Figure 5-5.

The system memory provides storage for ECG data, printer image construction, signal processing needs, and system software.

The DRAM gate array controls RAM operations, including read, write, and refresh cycles. The refresh cycle continues when the cardiograph is in **Standby**. The DRAM gate array also provides the following:

- A watchdog timer—shuts off the system after a software selected delay if not reset by software.
- A real-time counter (RTC)—keeps track of elapsed time since the last RTC reset.
- Power supply support—manages the power-on and power-off event sequences.

The data transceivers buffer the data on the CPU data bus to provide adequate drive for the RAM array.

The system memory circuitry remains energized regardless of whether the cardiograph is **On** or in **Standby**. The only times that power is lost to system memory are when:

- The battery is not installed *and* the cardiograph is disconnected from AC power.
- The cardiograph enters the low battery shutdown condition.

When all power is lost to system memory, its stored data is lost including the configured software. This makes it necessary to reload the software from disk.

ROM

The read-only memory consists of a 64K×16 EPROM (M1700A and M1701A), which stores the code that starts the system. The M1702A read-only memory consists of a 128k x 16 EPROM, which stores the cardiograph software.

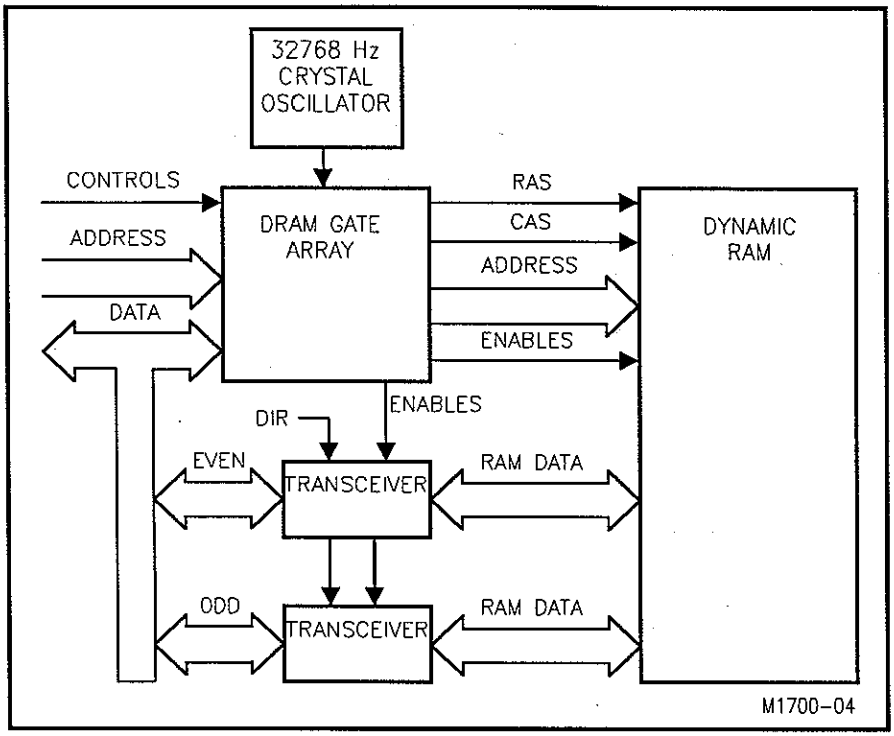


Figure 5-5. System Memory Block Diagram.

I/O Control

The I/O control circuitry handles the system input and output. The block diagram in Figure 5-6 shows the major elements.

The FGA

The primary element in the I/O control is the "Foundation" gate array (FGA). It provides the following functions:

- Keyboard interface
- Data bus arbitration
- Transmit portion of the patient module interface
- Enable and Select generation
- System clock generation
- Baud rate generation

The FGA, in its role as keyboard interface, sends and receives data directly to and from the keyboard through a 1200 baud serial interface.

As data bus arbitrator, the FGA enables and controls the direction of the data transceivers that buffer system data. The FGA also generates the read and write enable signals and the chip select signals for all I/O devices.

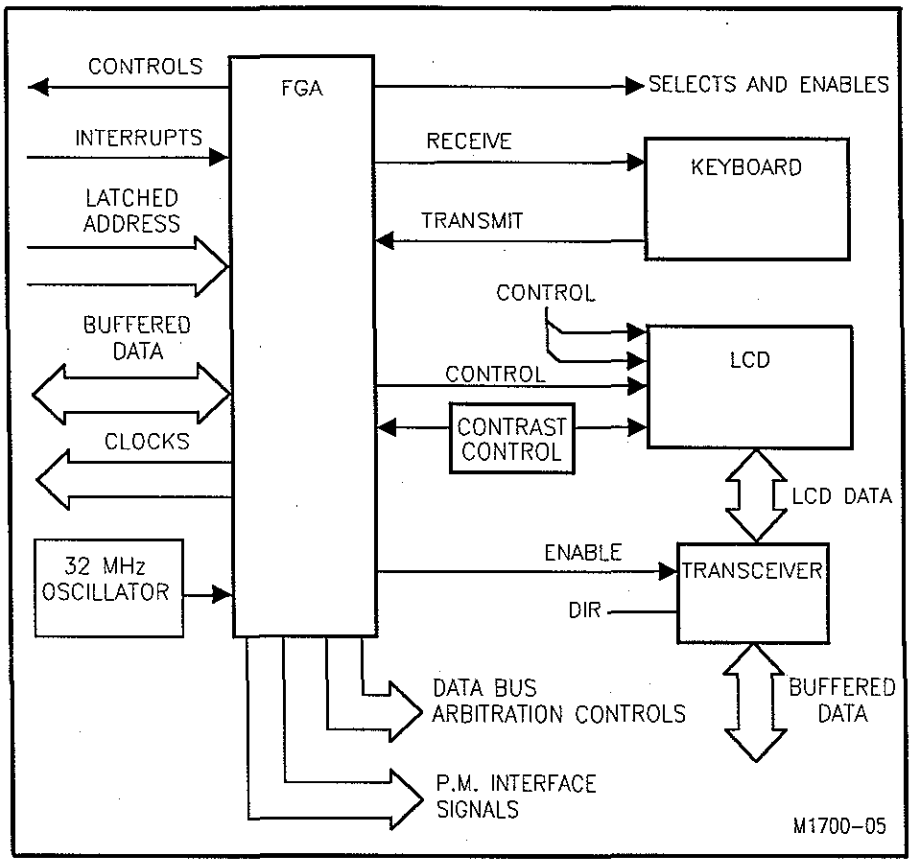


Figure 5-6. I/O Control Block Diagram.

Serial Communications

The other important element in the I/O control circuitry is the serial communications block (shown in Figure 5-7), which provides asynchronous serial communication for direct connect or modem. The universal asynchronous receiver/transmitter (UART) circuit provides buffering, parity, handshake logic, interrupt capabilities, and parallel-to-serial conversions for sending and receiving RS-232 data. The driver/receiver circuit converts serial signals between RS-232 voltage levels and TTL levels.

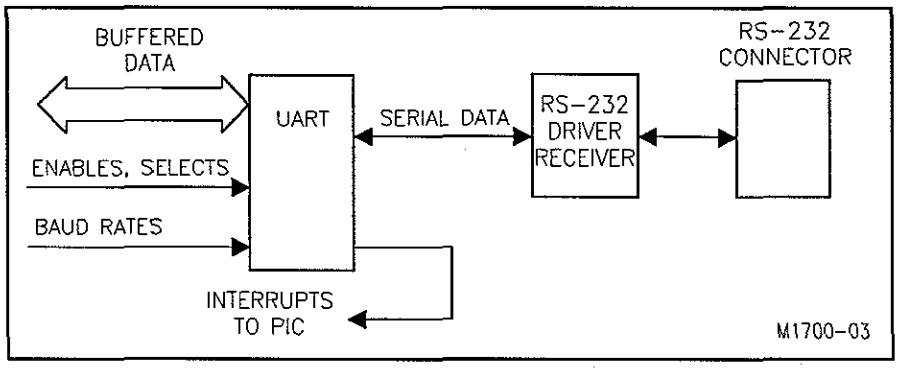


Figure 5-7. Serial Communications Circuitry.

Digital Signal Processor

The digital signal processor (DSP) assembly consists of a Motorola 56001® digital signal processor and three static RAMs that provide 32K words (24 bits-per-word) of memory. Refer to Figure 5-8.

The DSP provides a high-speed, synchronous interface for 24-bit serial data from the patient module, and digital filters for ECG data.

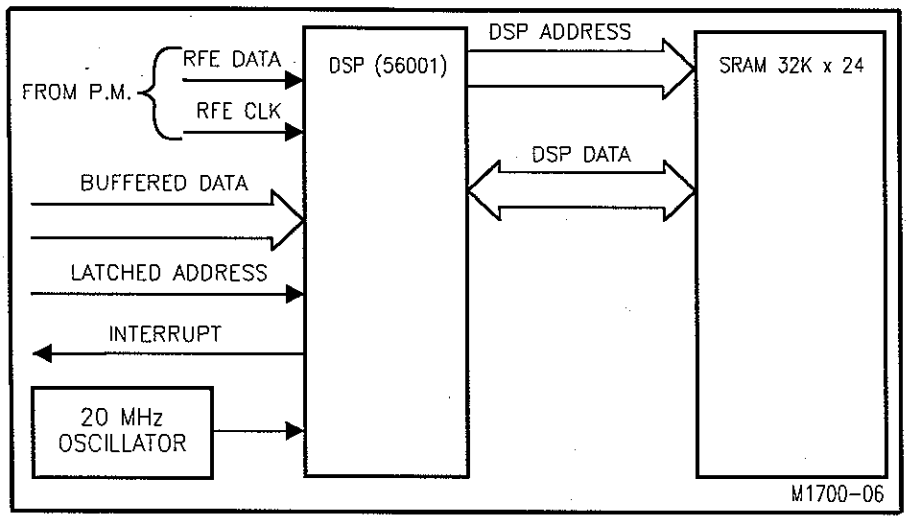


Figure 5-8. Digital Signal Processor Block Diagram.

System Expansion Connector

The system expansion connector, J12, provides the CPU signals and power sources required by the preview display assembly. The pin assignments for this connector are listed in Appendix A.

Disk Drive (M1700A and M1701A only)

The disk controller on the CPU assembly (see Figure 5-9) provides the interface to the system data bus for the 3.5-inch disk drive. The disk drive connects to the CPU assembly through two connectors, J14 (disk power) and J15 (data and control signals). Pin assignments for these connectors are described in Appendix A.

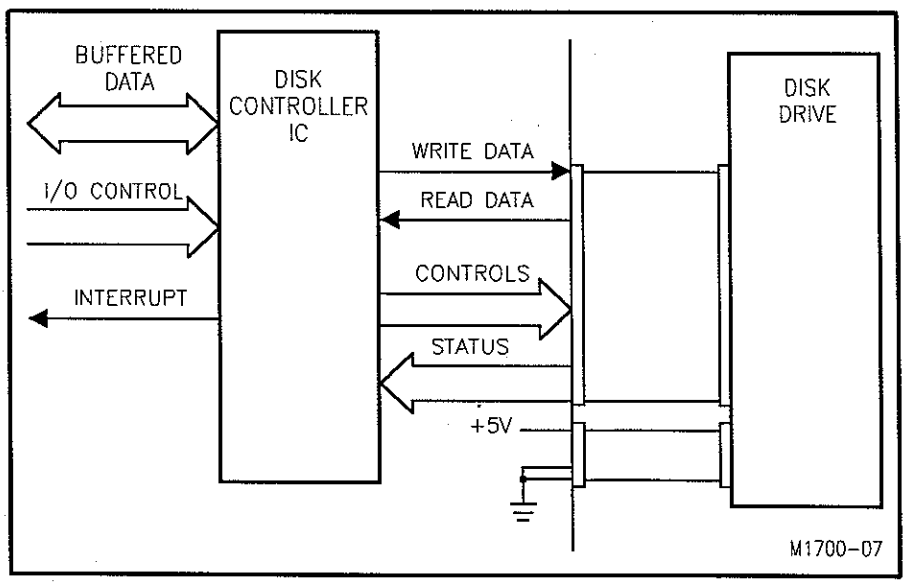


Figure 5-9. The Disk Drive and its Control Circuit.

Power Supply

The power supply's basic tasks are to charge the battery when the cardiograph is connected to AC power, provide +5 volts to the system logic, provide power to the printer, and provide operating voltage to the patient module. These are the circuits that make up the power supply:

- Battery Charger and Battery Sensor
- 5 Volt Regulator
- +5 Overvoltage/Undervoltage Sensor
- Printer Switch
- Battery Switch
- ACON Detector
- +5 Backup Supply and Low Battery Disconnect
- +5-to-Backup Switchover
- Patient Module Voltage Regulator

Note

Although the power supply circuits are discussed separately from the CPU assembly, they are all physically located on the CPU assembly except for the battery, the transformer, and the diode assembly cable, which includes the rectifier and filter capacitors.

Figure 5-10 shows how these circuits connect to each other and to other parts of the system.

VMAIN and VIN

VMAIN connects to the CPU assembly at J6 and J7. It is the unregulated, rectified AC that comes from the main transformer and bridge rectifier assembly. After passing through a fuse, VMAIN becomes VIN, which supplies power to the +5 volt regulator, the patient module regulator, and the preview display assembly.

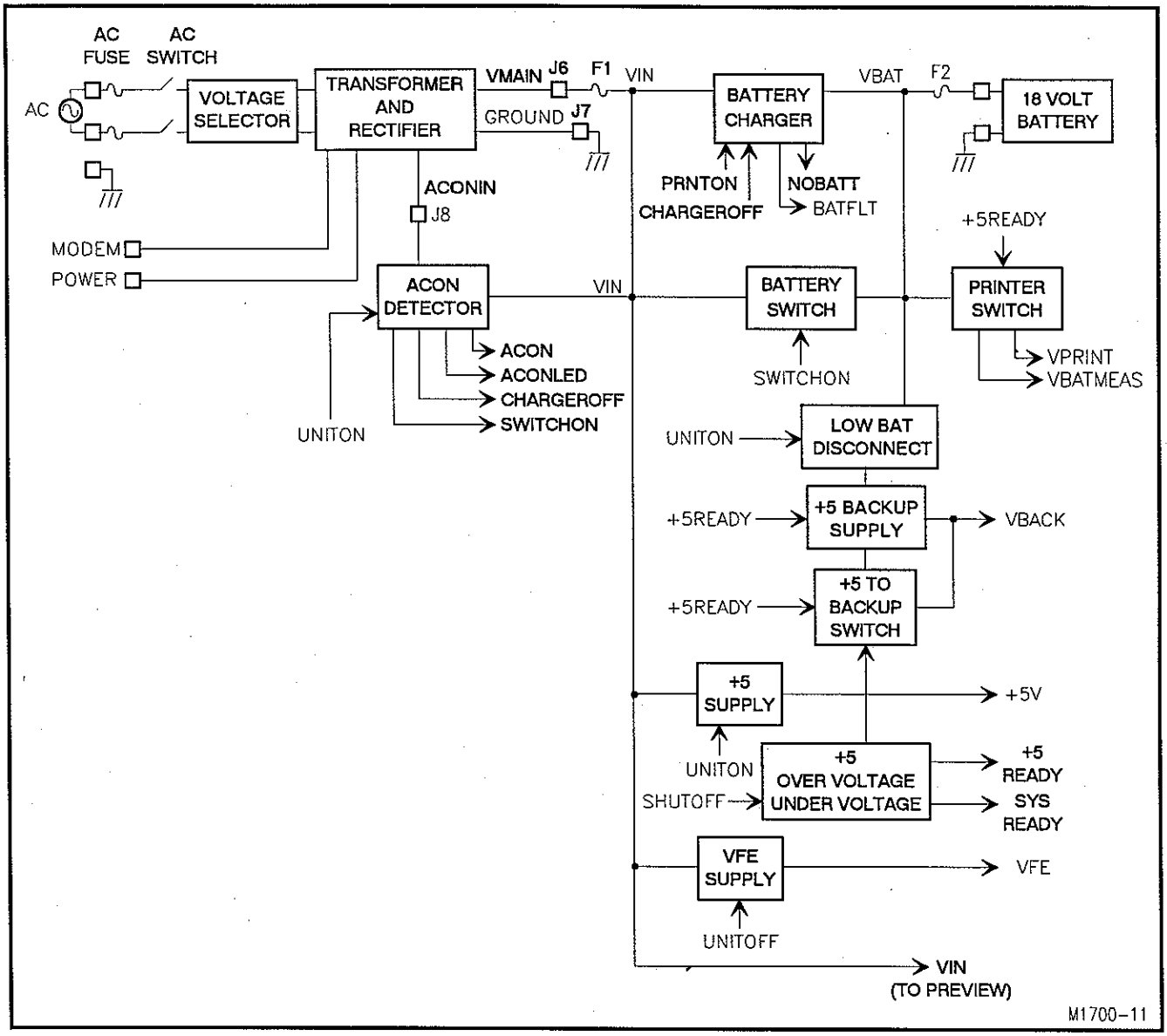


Figure 5-10. Power Supply Block Diagram.

Battery Charger and Battery Sensor

The battery charger converts VIN (15 to 31 volts) to VBAT (20 to 22 volts). VBAT connects to the + terminal of the battery through a fuse, which is located on the CPU assembly. The battery connects to the CPU assembly at J4. Pin assignments for the battery connector are listed in Appendix A, "Pin Assignments." The converter is of the "buck-boost" type. It is actually a "buck" rectifier connected to a "boost" (step-up) regulator so that the output voltage can be higher or lower than the input voltage.

Two circuits provide current limiting. One limits charging current to the battery to 1.7 amps average. The other current limit circuit limits the charger output current to a peak 5 amps. This has two purposes:

- To limit peak current during power-on and power-off.
- To limit peak current from the battery charger during printer power-on. When the printer turns on, it can draw peaks of current as high as 20 amps. The battery and battery charger provide this current. This current limit circuit helps prevent overstressing the switching FETs.

There are two output voltage modes, cycle and float. The charger enters cycle mode when the charging current exceeds 400 to 700 mA. In cycle mode, the output voltage is fixed at approximately 21 to 22 volts. The charger enters float mode when charging current is less than 400 to 700 mA. In float mode, the output voltage varies inversely with battery temperature. The charger determines temperature by measuring a voltage across a thermistor in the battery.

Battery Operation and Condition

When operating on battery power, the cardiograph software monitors the battery and displays the amount of charge remaining on the front panel battery indicator. When the low battery indicator on the front panel illuminates, the battery has discharged to the low battery warning point. The cardiograph can continue to operate in this condition until it reaches the low battery shutdown point.

The low battery shutdown point occurs when the battery is approximately 70% discharged. The low battery indicator begins flashing and the message "`Low battery, plug cardiograph into AC.`" is displayed. After one minute, the cardiograph will go to **Standby** unless it is connected to AC before the minute expires. If the battery is not allowed to recharge, it will continue to discharge until it reaches the low battery disconnect point.

Low battery disconnect occurs when the battery is approximately 80% to 90% discharged. When this occurs, the battery is completely disconnected from the system, and memory and clocks are lost. The disconnect circuit is described later in this section.

5 Volt Regulator

The 5 volt regulator provides logic power to the cardiograph. This regulator converts VIN to +5 volts ±5% with a "buck" (step-down) converter. The UNITON signal from the DRAM gate array turns the regulator on and off, and soft-start circuitry prevents voltage overshoot at start-up. Maximum rated output current is 3 amps.

+5 Overvoltage/ Undervoltage Sensor

This circuit monitors the +5 volt supply to sense an overvoltage or undervoltage condition.

When the (On-Standby) key is pressed to turn the cardiograph **On**, +5READY goes high as soon as +5 volts is within regulation. +5READY enables the printer switch and preview display, and disables the backup supply. After about 100 ms SYSRDY goes high. This delay allows the VBACK supply to equalize voltage with the +5 volt supply.

When the (On-Standby) key is pressed to place the cardiograph in **Standby**, the system software enters the power-off sequence described earlier in this chapter. The DRAM gate array asserts the SHUTOFF signal, which causes +5READY and SYSRDY to go low. When +5READY goes low, it disconnects the printer switch and enables the backup supply, which provides power to the DRAM. After 30 to 60 ms, the UNITON signal goes low and turns off the +5 regulator.

As long as the supply remains within tolerance, the +5READY and SYSRDY signals remain high. When the +5 volt supply exceeds the tolerance in either direction, +5READY goes low.

Printer Switch

This block consists of two separate circuits: the printer switch and the voltage reference.

The printer switch provides battery power, VBAT, to the printhead and printer motor. The signal name for the switched power is VPRINT. The switch, which consists of three power FETs, closes when +5READY goes high. A voltage divider scales down VPRINT to produce VBATMEAS. The print circuitry uses VBATMEAS to update the front panel battery level indicator, to initiate low battery shutdown if necessary, and to provide printhead voltage to the printer gate array.

Battery Switch

This circuit connects the battery (VBAT) to VIN when the cardiograph is not connected to AC power. This provides power to the +5 and patient module voltage regulators and to the preview power supply. The switch, which consists of three FETs, closes when SWITCHON (from the ACON circuit) is high.

A diode in the circuit isolates VIN from the battery during printer current surges.

ACON Detector

This circuit generates the SWITCHON signal that controls the battery switch, and the CHARGEROFF signal that controls the battery charger. When the cardiograph is running on battery power, the CHARGEROFF and SWITCHON signals are high, which disables the battery charger and enables the battery switch, respectively. When running on AC power, CHARGEROFF and SWITCHON are low, enabling the battery charger and disabling the battery switch. The ACON circuit samples AC voltage directly off of the main transformer secondary, rectifies it, and compares it to a reference voltage from the backup supply. ACON is high when AC power is on.

ACONLED drives the AC indicator LED on the front panel.

+5 Backup Supply and Low Battery Disconnect

The +5 backup supply (VBACK) provides power for DRAM and associated logic when the cardiograph is in **Standby**. When the cardiograph is **On** and the +5 supply is in operation, the backup supply is disabled and the +5 supply is connected to VBACK.

The low battery disconnect circuit will disconnect the battery from the backup supply when the battery is approximately 80% discharged. This will occur only when the cardiograph is in **Standby** *and* is disconnected from AC power. The disconnect circuit is disabled when UNITON is high. This avoids tripping the disconnect circuit when battery voltage dips momentarily due to load.

Note

When this circuit disconnects the battery, power to DRAM is lost, resulting in the loss of system software and configuration data. The software and configuration data must be reloaded from disk before the cardiograph can be used.

+5 to Backup Switchover

At power-on, this circuit connects the +5 V supply to VBACK as soon as +5 V comes into regulation (+5READY goes high). At power-off, this circuit disconnects +5 V from VBACK.

Patient Module Voltage Regulator

This circuit provides power (VFE) to the patient module. The regulator is enabled when UNITOFF (from the DRAM gate array) goes low, and is disabled when UNITOFF goes high. Output voltage is between 10.0 and 11.5 volts at 0 to 220 mA load. In the disabled state, output voltage is about 1.3 volts while running off of AC, and 0 volts while running off of the battery.

The Keyboard and Keyboard Display

The keyboard and the keyboard display constitute the front panel controls and indicators. They share a connector that plugs into the CPU assembly at J1 (refer back to Figure 5-2). Pin assignments for J1 are listed in Appendix A.

The keyboard consists of the control switches, the alphanumeric keyboard, and the LED indicators. The keyboard communicates with the CPU assembly over serial transmit and receive lines. The system reads keycode information on the transmit line, and writes LED indicator information on the receive line. While the cardiograph is in **Standby**, the (On-Standby) key is connected to the system by a separate signal line; when the cardiograph is **On**, the (On-Standby) key is also encoded like the other keys. The AC indicator is driven by the system through a separate signal line.

The keyboard display is a 40-character, 2-line, alphanumeric LCD. It receives 8-bit data from the system, and control signals from the FGA.

Printer

The cardiograph's printer consists of the control and drive circuitry on the main circuit board, the thermal printhead, and the paper transport mechanism. The block diagram in Figure 5-11 shows how these parts connect to each other and to the rest of the cardiograph.

Printer Gate Array

The printer gate array is the principal component of the printer control circuitry. It buffers print data coming from the system and status data going to the system, controls printer timing, controls the printer RAM, regulates motor speed, monitors printhead temperature and resistance, monitors the battery condition, and provides the interface between the printer and the system CPU.

Printer RAM

The printer RAM consists of 32 kilobytes of static RAM used to store printer data and the printer look-up table data. The look-up table data is used to compensate the motor drive signals and the printer enable pulses for variations in the operating environment. The look-up table data also includes the motor settings and the motor ramp-up profile.

Motor Driver

The phase signals from the printer gate array enable the motor driver circuit, which switches current through the stepper motor in the paper transport.

ADC (Analog-to-Digital Converter)

This is an 8-bit parallel A/D converter used to measure printhead temperature, battery voltage, and motor supply voltage.

Thermal Printhead

The thermal printhead is a line of 1728 printing elements. Each printing element is a resistive heater. Heat from these elements blackens the thermoreactive paper, creating an image. A 1728-bit shift register (on the printhead) contains the dot data for the print line. Data is serially loaded into the shift register, then latched so that data for the next line may be shifted into the head while the present line prints. A strobe signal enables printing. The pulse width of the strobe is adjusted to compensate for different recording speeds and variations in supply voltage, average heater resistance, and temperature, which is sensed by a thermistor on the printhead heat sink.

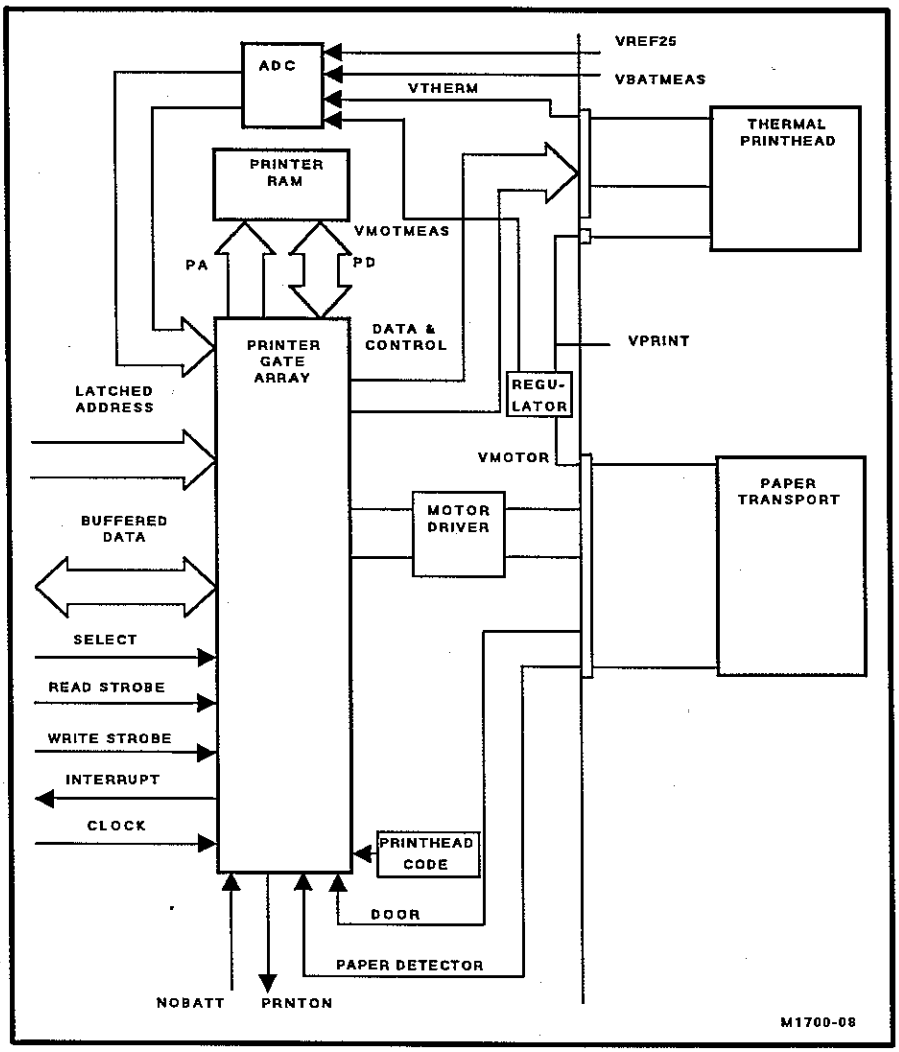


Figure 5-11. Printer Block Diagram.

The Preview Display

Note

The preview display is available only on the M1700A.

The preview display consists of three subassemblies:

- The preview logic board
- The preview power supply board
- The preview LCD

The preview logic board connects to the system expansion connector on the CPU assembly. The three subassemblies then connect to each other as shown in Figure 5-12. Pin assignments for the preview display connectors are listed in Appendix A.

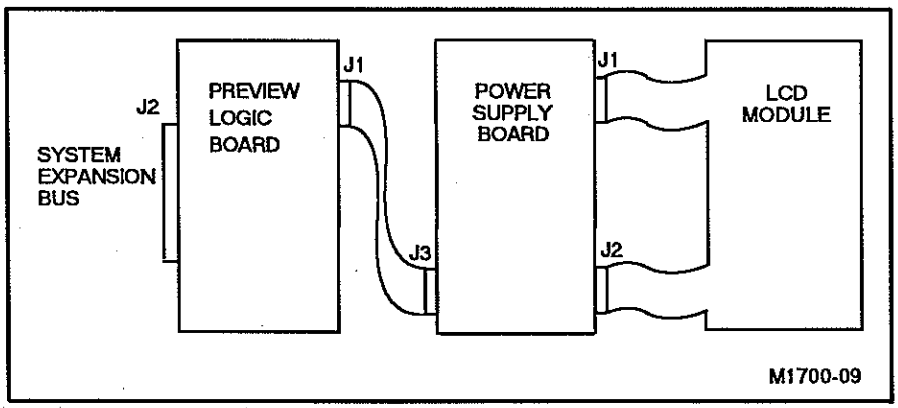


Figure 5-12. Preview Display Subassembly Connections.

Preview Logic Board

The preview logic assembly is diagrammed in Figure 5-13. The buffers reduce loading on the CPU address, data, and system control lines and ensure proper logic levels and transitions for the preview logic circuitry.

The address decoder determines whether the system has access to the LCD static RAM (SRAM) or the LCD controller. Upon recognition of the proper addresses, the decoder generates control signals that provide the following:

- read/write access to the LCD bit map stored in static RAM (SRAM) for display data reads and writes.
- write-only access to the LCD controller's internal control registers for I/O register writes (usually done at system initialization).

The SRAM address bus can be driven by the CPU or by the LCD controller. The address multiplexers, under the control of the LCD controller, select between these two address sources. In the event of contention, the LCD controller forces the CPU to wait for access to the RAM.

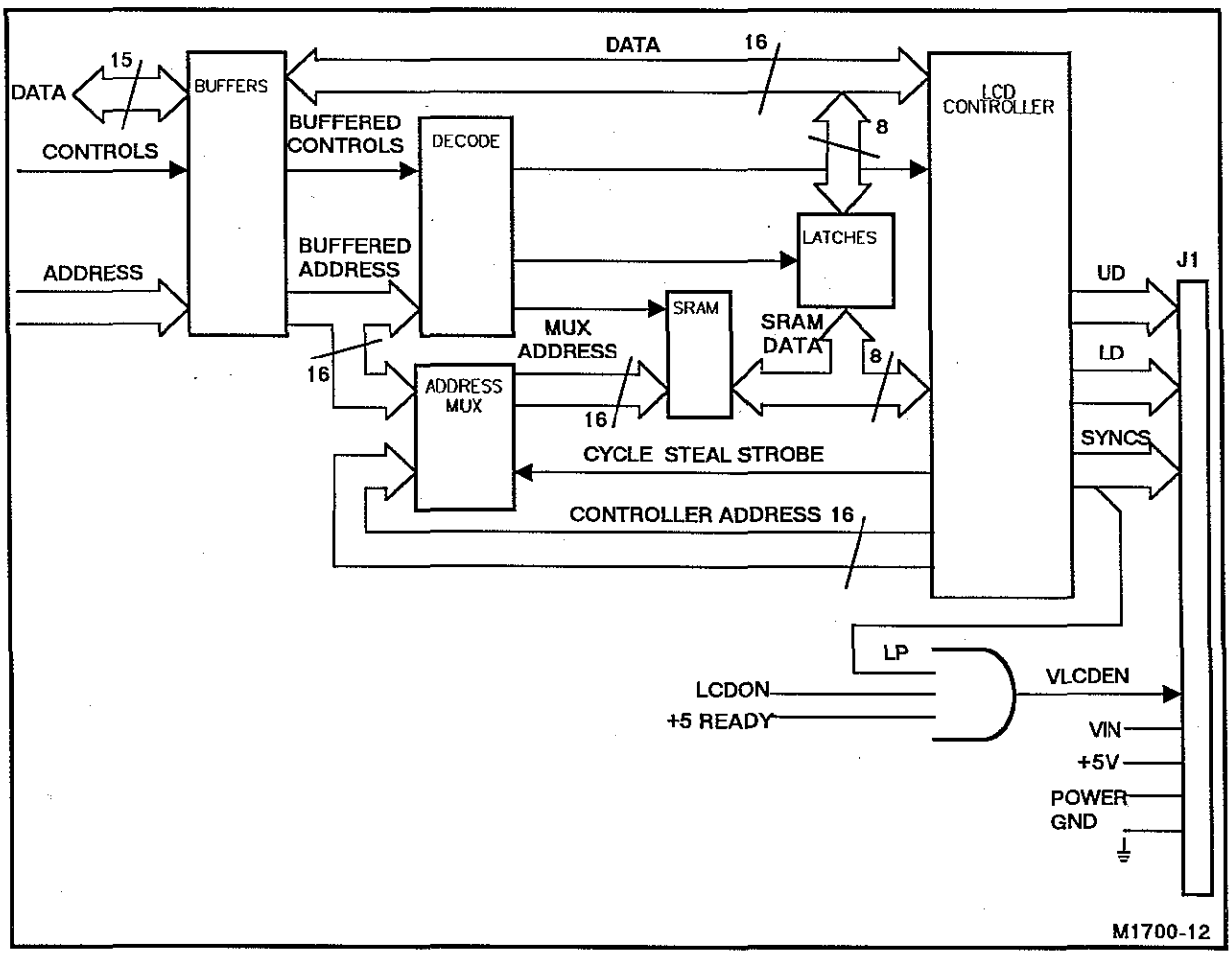


Figure 5-13. Preview Logic Board Block Diagram.

The SRAM is a CMOS 32K×8 static RAM that contains a complete graphics bit map of the LCD. Display data is written to or read from SRAM.

The LCD controller reads the display data from SRAM and outputs it on the upper and lower screen data lines (UD and LD). The controller also generates synchronization signals that send the data to the LCD.

The LCD enable circuitry generates the VLCDEN signal that allows the system to turn the LCD (and backlight) on and off. Functionally, this circuit is an AND gate that generates VLCDEN when +5 volts is stable (+5READY) *and* the system has turned on the LCD (LCDON). The latch pulse signal (LP) must also be present before the LCD can be turned on, thus preventing damage to the LCD.

The upper screen and lower screen data lines (UD and LD), sync signals (FP, LP, and SCP), VLCDEN, VIN, +5 volts (VCC), and GROUND leave the preview logic board and connect to the preview display power supply board.

Preview Display Power Supply Board

The preview display power supply board, shown in Figure 5-14, provides three sources of power to the LCD module:

- VCC (+5 V DC)
- VLCD (-6 to -23.5 V DC)
- VCFL (about 400 V RMS @ 30 kHz)

Note

The upper and lower screen data signals (UD and LD), and the sync signals (LP, FP, and SCP) pass unaffected through this board to the LCD module.

VCC, which is obtained from the main system +5V power supply, provides basic power to the LCD and its associated driver ICs. VLCD controls the LCD contrast (the optical characteristic of the LCD), and VCFL controls the LCD brightness (the intensity of the cold cathode fluorescent backlighting).

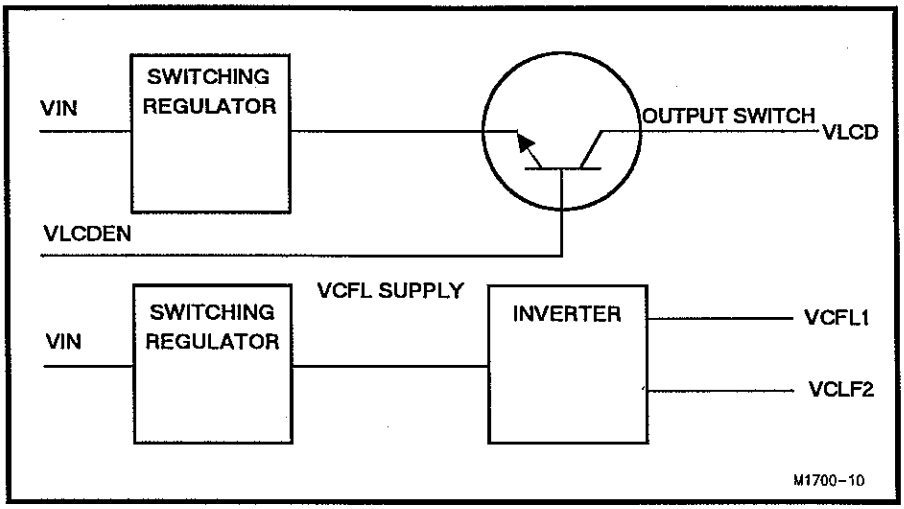


Figure 5-14. Preview Display Power Supply Block Diagram.

VLCD Supply

The VLCD (contrast) supply is a buck-boost type DC-DC converter that derives VLCD from VIN. The contrast potentiometer controls VLCD voltage level.

The series transistor in the output is a switch that is controlled by the VLCDEN signal. It prevents application of VLCD to the LCD module before VCC is stable at power-on, and switches off VLCD prior to VCC at power-off. This prevents damage to the LCD driver ICs.

The VLCDEN signal may be controlled by the CPU software, providing a software-controlled means of blanking the LCD.

VCFL Supply

The VCFL (brightness) supply consists of two stages. The first stage is a switching regulator that converts VIN into a voltage that is varied by the brightness potentiometer. The second stage is a high voltage inverter module that generates the high voltage AC signal necessary to operate the fluorescent lamps used for display backlighting.

Preview Screen

The preview screen is a 640×400 dot LCD with cold cathode fluorescent backlighting. The LCD driver circuitry receives control and data signals that originate from the preview logic board. The latch pulse (LP), frame pulse (FP), and shift clock pulse (SCP) control signals synchronize the LCD. The UD and LD lines provide display data to the LCD.

6

Troubleshooting

Introduction

This chapter provides information for localizing cardiograph problems to the subassembly level. This information is designed for use with the cardiograph's Extended Self-test to help you efficiently repair the cardiograph with a minimum of equipment.

Maintenance Philosophy

The maintenance philosophy for the cardiograph is subassembly replacement. Replaceable subassemblies are identified in Chapter 8, "Parts List".

Caution

Individual component replacement should not be attempted outside of an authorized Hewlett-Packard repair facility. Component level repair is extremely difficult due to the extensive use of surface mount technology and the high parts density on the circuit boards. Unauthorized component replacement can impair cardiograph performance and jeopardize credit towards a replacement assembly.

Test Equipment

The following test equipment is required to troubleshoot the cardiograph as described in this chapter:

- A digital voltmeter such as the Hewlett-Packard E2373A hand-held multimeter.
- A 12-lead ECG simulator.
- A blank 1.44-Mb disk (not needed with M1702A).

The Error Log

All events that produce displayed errors place those errors into the error log (this does not include power-on errors, or operator error messages such as an out of paper message). The error log can be printed by entering Extended Self-test and selecting the `ErrorLog` key as explained in Chapter 4. The printed error log includes four fields for each logged error (see Figure 6-1):

Error	The error code. Useful in diagnosing what is happening in the cardiograph. Frequent errors of the same type are indications of a problem, especially if they are logged close together in time.
Date	The date the error occurred (as set on the cardiograph).
Time	The time the error occurred (as set on the cardiograph).
Status	This field is reserved for factory use. It may help factory personnel assist on very difficult problems. The error log lists the 100 most recent events.

Clearing the Log

The stored error log is cleared each time the software is reloaded, whether from the System disk that comes with the cardiograph, or from a user's configuration disk.

If you are troubleshooting a problem, you should print the error log before you reload the software. This can assist in determining the cause of the failure. If the failure disappears after reloading the software, the loaded software may have been corrupt. If the failure continues after reloading the software and produces the same error code, a hardware problem is likely.

ERROR LOG LOC 00000 - 0000 04/01/1990 02:47:09 PM

Error	Date	Time	Status
05007	01/01/1989	00:01:16	0000000
03510	03/30/1990	15:00:20	0000005
04007	03/30/1990	15:04:00	0006002
04007	03/30/1990	15:04:46	0006002
04007	03/31/1990	08:18:08	0006002
04007	03/31/1990	08:20:15	0006002
05007	03/31/1990	08:20:52	0000000
03510	03/31/1990	08:22:40	0000005
03510	03/31/1990	08:23:55	0000005
03510	03/31/1990	08:24:01	0000005
03510	03/31/1990	08:25:16	0000005
04003	03/31/1990	08:26:43	0000005
04003	03/31/1990	08:26:43	0000011
05007	03/31/1990	08:27:50	0000000
05007	03/31/1990	08:31:51	0000000
05007	03/31/1990	09:00:31	0000000
03510	03/31/1990	09:04:24	0000005
03510	03/31/1990	09:04:44	0000005
03510	03/31/1990	09:06:07	0000005
05007	03/31/1990	09:07:39	0000000
05007	03/31/1990	09:07:51	0000000
03510	03/31/1990	09:08:03	0000005
03510	03/31/1990	09:08:35	0000005
03510	03/31/1990	09:09:23	0000005
03510	03/31/1990	09:12:37	0000005
03510	03/31/1990	09:13:29	0000005
03510	03/31/1990	09:14:57	0000005
05007	04/01/1990	11:24:30	0000000
05007	04/01/1990	11:24:35	0000000
03510	04/01/1990	11:25:49	0000005
03510	04/01/1990	11:28:07	0000005
03510	04/01/1990	11:28:13	0000005
05007	04/01/1990	11:29:47	0000000
05007	04/01/1990	11:30:38	0000000
05007	04/01/1990	12:42:01	0000000
05007	04/01/1990	12:43:18	0000000
03510	04/01/1990	12:45:30	0000005
05007	04/01/1990	14:37:16	0000000
05007	04/01/1990	14:37:40	0000000
05007	04/01/1990	14:38:34	0000000

Error	Date	Time	Status
05007	04/01/1990	14:39:24	0000000
05007	04/01/1990	14:39:33	0000000
05007	04/01/1990	14:40:42	0000000
05007	04/01/1990	14:40:57	0000000
05007	04/01/1990	14:39:24	0000000

HP-001

Figure 6-1. Sample Error Log Printout.

Errors

The following list describes the errors that can appear in the error log.

Error	Description
1499	This error occurs when the software detects an error that cannot be corrected. Set the cardiograph to **Standby** then back to **On** and check if the error repeats. If the error repeats, use Extended Self-test to help locate the failure. Extended Self-test is explained in Chapter 4. If Extended Self-test does not locate the problem, print out the error log, then reload the software from the System Disk that came with the cardiograph. If the failure persists, replace the CPU assembly.

1540	This error is logged when the message `Data transmission abnormal termination.` appears. The error is received from the remote system, and the Status field on the printout shows the error passed by that system.
1541	This error is logged when the message `Data transmission abnormal termination.` appears and indicates a transmission problem at the local cardiograph. Try each of these possible remedies: 1. Check cabling 2. Retry the operation 3. Use a different phone line 4. Check with the system operator to find out if abnormalities exist at the other end
9000–9499	Errors in this range indicate a communication problem between the cardiograph and the patient module. The problem can be caused by hardware or software, and can occur in the cabling, the CPU assembly, or the patient module. To locate and correct the problem, use these actions: 1. Check all cables 2. Cycle the power 3. Run Extended Self-test 4. Reload the software 5. Refer to the troubleshooting table for the patient module and cable

Using Extended Self-test in Troubleshooting

The cardiograph's Extended Self-test is a simple-to-use, looping test that gives you pass/fail status for each of these major subassemblies:

- Patient module and cable
- CPU assembly
- Printer
- Disk drive (M1700A and M1701A only)
- Preview display (M1700A only)
- Keyboard display
- Modem and cable (M1700A only)
- Fax modem (M1756A only)

Instructions for entering and using Extended Self-test are found in Chapter 4, "Performance Verification and Maintenance."

The messages in the following list are Extended Self-test's failure messages. If a subassembly test fails, the failure message for that subassembly appears in the keyboard display. The message remains there until you set the cardiograph to **Standby** (or it shuts itself off to preserve the battery). Because the keyboard display is tested entirely with a test pattern, there is no failure message for the keyboard display test. Test pattern errors must be visually detected while the test patterns are displayed. This is also true for the test patterns displayed on the preview screen, the patient module display, and the printer.

- `Patient module test failed.`
- `Patient module cable test failed.`
- `CPU assembly test failed.`
- `Printer test failed.`
- `Disk drive test failed.`
- `Preview test failed.`
- `Modem test failed.`

Troubleshooting Tables

The troubleshooting tables in this section help you to localize a fault and correct it. The troubleshooting flowchart in Figure 6-2 guides you to the troubleshooting table that covers a particular functional area of the cardiograph.

Table 6-1 lists errors that can occur only during the power-on routine and will appear only as numbers on the display. The table defines and explains each error, and suggests one or more corrective actions for each. All the other tables list failure symptoms, possible causes, and suggested remedies.

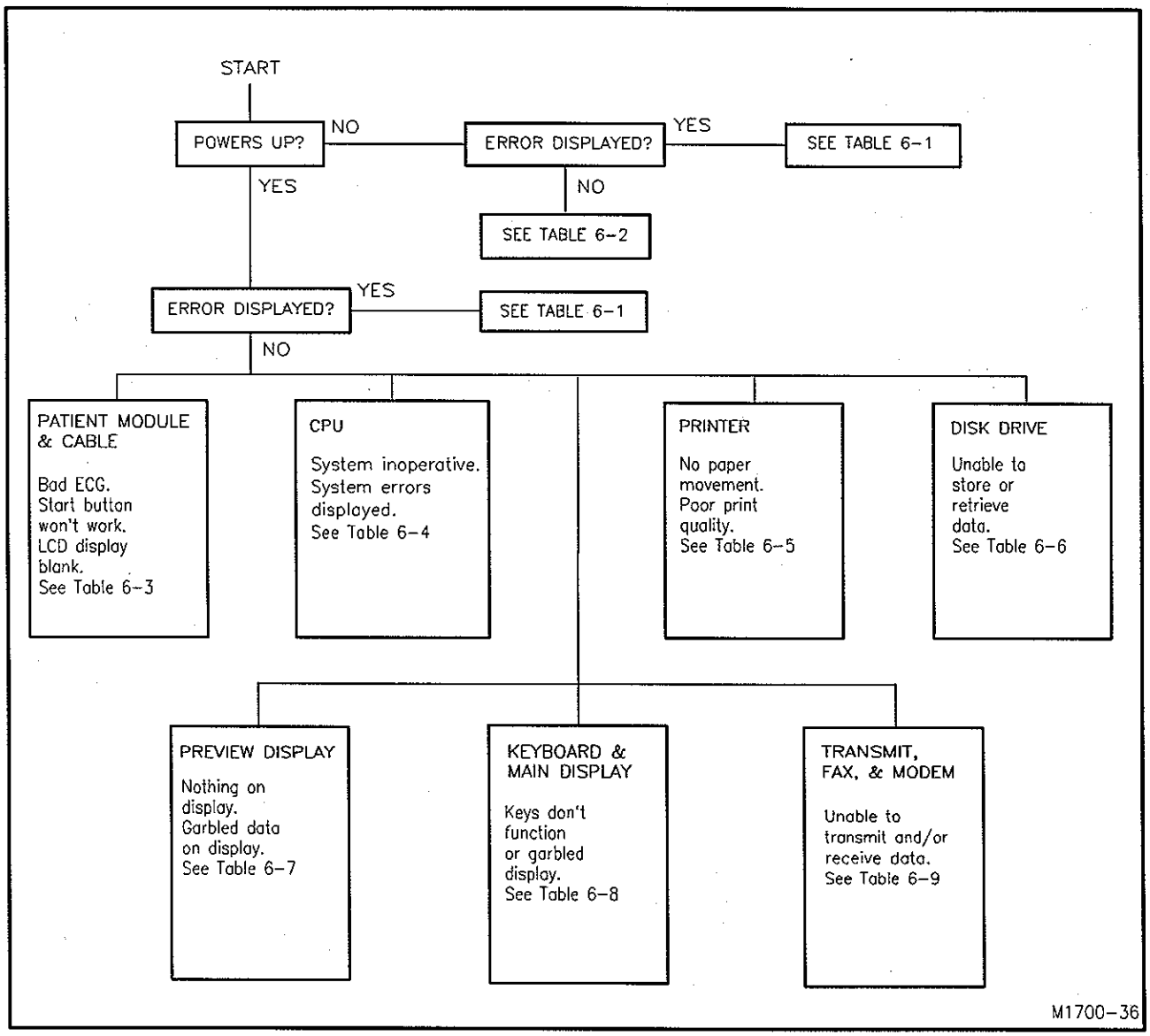


Figure 6-2. Troubleshooting Flowchart.

Caution

Before removing or inserting any board or connector, make sure AC power is off, the battery is removed, and the rectifier assembly capacitors are discharged.

Note

In Table 6-1, the corrective action "Cycle power" means to press the On-Standby key repeatedly to turn the cardiograph to **Standby** and back to **On**.

Tip

If the cardiograph will not turn on or operate and displays an error code, the preview logic board may be defective and causing these symptoms. Try disconnecting the preview logic board to eliminate it as the source of the power-on problems.

Table 6-1. Power-on Errors

Error #	Definition	Corrective Action
6500	Defective ROMs or other related hardware problem on CPU assembly.	Replace CPU assembly.
6501	Failed to initialize disk controller. Disk drive connecting cable bad, disk drive bad, or CPU assembly bad.	1. Replace cable. 2. Replace disk drive. 3. Replace CPU assembly.
6502	Failed to complete loading of software.	Reload software.
6503	No RAM code found in machine. A.01.00 software defect.	1. Reload software. 2. Load software version A.01.01 or later. 3. Replace CPU assembly.
6504	RAM cyclic redundancy check (CRC) failed—RAM code corrupt after loading code.	Reload software.
6505, 6506	Insufficient memory. M1700A software loaded into an M1701A.	1. Load proper software. 2. Replace CPU assembly.
6600, 6601	Catastrophic software failure.	Reload software.
6602	Failures in power-on routine.	1. Cycle power. 2. Reload software. 3. Replace CPU assembly.
6605, 6609, 6610	Missing message table. Disk could be bad.	Reload software.
6606, 6607	Failures in power-on routine.	1. Cycle power. 2. Reload software. 3. Replace CPU assembly.
6612	Wrong message table version.	Reload software.
6613, 6614, 6615, 6616	Software failure.	Reload software.
6990, 6991	Software corrupt.	Reload software.

Note

To reload the software on the M1702A XLe, remove the battery, then reinstall the battery and reconfigure the unit.

Table 6-2. Power Supply and Battery

Symptom	Cause	Corrective Action
Message: `No battery. Load battery.` Cardiograph won't turn on.	Battery not installed.	Install the battery, then try turning on the cardiograph.
One or more power supply voltages missing (see "Testing the Power Supply" at the end of this chapter).	Defective regulator circuit(s).	Replace CPU assembly.
AC indicator not lit.	Power cord unplugged. AC switch is off. AC fuse is blown. ACON connector not plugged in. Bad user interface cable. Bad keyboard circuit board. VMAIN connector (J6) not plugged in on CPU assembly. VBACK or VBAT regulator defective. VMAIN or VIN not present.	Plug in power cord. Turn on AC switch. Replace AC fuse. Plug in ACON connector. Replace cable. Replace user interface assembly. Plug in VMAIN connector. Replace CPU assembly. Check for VMAIN and VIN on CPU assembly (see "Testing the Power Supply" at the end of this chapter). If only VIN missing, replace CPU assembly. If both missing, replace rectifier assembly.
Cardiograph doesn't run on battery, but runs on AC.	Low battery or defective battery. Battery fuse (F2) is blown. Battery charger is defective. Battery switch is defective.	Charge or replace battery. Check for VBAT and VBAT+ on CPU assembly. Replace fuse if VBAT is not present. Replace CPU assembly. Check for VIN when the (On-Standby) key is pressed. Replace CPU assembly if VIN is not present.

Table 6-2. Power Supply and Battery (continued)

Symptom	Cause	Corrective Action
Cardiograph doesn't run on AC, but runs on battery.	Voltage selector switch set to wrong voltage.	Set switch to correct voltage.
	AC fuse is blown.	Replace AC fuse.
	ACON connector (J8) not plugged in.	Plug in ACON connector.
	Rectifier assembly, transformer, AC switch, power line module, or power cord defective.	Check for VMAIN and replace appropriate assembly to restore VMAIN.
	VIN fuse (F1) is blown.	Check for VMAIN and VIN. If VIN is not present, replace CPU assembly.
	Input protection transorb is defective.	Check for VMAIN. If not present, replace CPU assembly.
Cardiograph won't power up on AC or battery.	User interface cable is defective.	Replace the user interface cable.
	Keyboard circuit board is defective.	Replace the user interface assembly.
	VBACK regulator is defective.	Replace CPU assembly.
	+5 volt regulator is defective.	Replace CPU assembly.
Battery charge level indicator never indicates full capacity.	Battery not fully charged.	With unit plugged into AC power, turn on unit and observe battery level indicator. If all green lights are on, battery is fully charged. If some green lights are not on, battery needs further charging.
	Battery is defective.	Replace battery.
	Keyboard circuit board is defective.	Replace the user interface assembly.
	Battery fuse (F2) or VIN fuse (F1) (or both) defective.	Replaces fuse(s).
	Battery charger is defective.	Replace CPU assembly.
	CPU assembly is defective.	Replace CPU assembly.
	Indicator is not updated.	Connect to AC power and power on.
Battery charge level indicator always indicates full capacity on AC power with battery.	Keyboard circuit board is defective.	Replace user interface assembly if Extended Self-test keyboard test shows LED is out.
	Battery is defective.	Replace battery.
	Battery fuse (F2) is open.	Replace fuse.
	CPU assembly is defective.	Replace CPU assembly.

Note Only the M1700A and M1701A patient modules feature a display and a start button.

Note

When dealing with noise problems, remember that most noise is the result of faulty operator technique or poor quality electrodes. If noise persists after checking the electrode placement and other elements of operator technique, the noise may be the result of faulty leadwires. Only when you eliminate technique and leadwires as the causes of the noise should you consider replacing the patient module.

Tip

The leadwire status indicators on the patient module and the leadwire shorting plugs can be used as a troubleshooting aid. With the SAECG patient module, these indicators are only active until the Start key is pressed.

Table 6-3. Patient Module and Patient Data Cable

Symptom	Cause	Corrective Action
No display on patient module LCD M1700A & M1701A only.	Incorrect contrast adjustment. Patient data cable or cable connectors. Defective patient module. Defective part on CPU assembly.	Adjust contrast. Tighten if loose, replace if damaged or defective. Replace patient module. Replace CPU assembly.
"Leads off" displayed on preview screen, but patient module appears blank or shows stars, blanks, and boxes.	Loose or defective patient data cable, cable connectors. Defective patient module. Defective part on CPU assembly. Averaging in SAECG.	Check cable and connectors for damage. Tighten connectors as necessary. Replace damaged cable. Replace patient module. Replace CPU assembly. None (stars normally appear during averaging).
"Leads off" not indicated when wire is off.	Dirty contacts on patient module for leadwires. Defective patient module. Defective or dirty leadwire.	Ensure the contacts on the patient module are clean and dry. Replace patient module. Clean and switch to isolate defective leadwire. Replace defective leadwire.
"Leads off" indicated when wire is not off.	Poor electrode contact. Defective leadwire.	Improve patient preparation. Remove leadwire and install shorting plug. If "leads off" isn't indicated, replace leadwire; if "leads off" is indicated, replace the patient module.
No response to start button (M1700A & M1701A only).	Cardiograph busy. Insufficient pressure on start button. Defective patient module. Suspect patient module if cardiograph starts from front panel but not from patient module button. Cardiograph is in SAECG mode (start button is not active in this mode).	Verify cardiograph is not in configuration mode or busy. Push harder. Replace patient module. None.
All "Leads Off" printed on a copy of M1702A ECG. (M1702A only)	ROM Software Defect. A.01.00 Patient was disconnected before copy button was pressed.	Install A.01.01 (or later) Revision ROM.

Table 6-3. Patient Module and Patient Data Cable (continued)

Symptom	Cause	Corrective Action
Bad ECG:		
Good calibration pulse in channel(s) where trace(s) is(are) not good.	Faulty operator technique; poor electrode contact.	Refer to Table 6-1 in user's manual.
	Defective leadwires.	Isolate defective leadwires and replace.
	Defective patient module.	Replace patient module.
A lead is missing—dotted line on trace.	Faulty operator technique; poor electrode contact.	Refer to Table 6-1 in user's manual.
	Defective leadwires.	Isolate defective leadwires and replace.
	Defective patient module.	Replace patient module.
Noisy lead(s): "AC" (regular pattern)—for 60 Hz, 12 peaks/5 mm at 25 mm/sec; for 50 Hz, 10 peaks/5 mm.	Faulty operator technique; poor electrode contact.	Refer to Table 6-1 in user's manual.
	Patient or patient module cable near AC power.	Reposition patient module cable. Try plugging cardiograph into AC outlet.
Noisy lead(s): Muscle artifact.	Patient is not relaxed or skin has been irritated.	Refer to Table 6-1 in user's manual.
	Low quality disposable electrodes, leadwire adapters.	Replace disposable electrodes or leadwire adapters.
		Test with ECG simulator. Replace defective leadwire(s). If none defective, replace patient module.
Noisy lead(s): I, III, aVL	LA leadwire defective.	Replace LA leadwire.
Noisy lead(s): II, III, aVF	LL leadwire defective.	Replace LL leadwire.
Noisy lead(s): I, II, aVR	RA leadwire defective.	Replace RA leadwire.
Noise in only one V lead.	Faulty operator technique; poor electrode contact.	Refer to Table 6-1 in user's manual.
	Defective leadwires.	Isolate defective leadwires and replace.
Noise in general.	Faulty operator technique; poor electrode contact.	Refer to Table 6-1 in user's manual.
	Defective leadwires.	Isolate defective leadwires and replace.

Table 6-4. CPU Assembly (CPU, FGA, ROM, RAM)

Symptom	Cause	Corrective Action
System won't turn on, battery installed and OK.	Defective CPU assembly.	Replace CPU assembly.
System turns on but won't run. Power supplies OK.	Stored software corrupt. Defective CPU assembly.	Reinstall software. Replace CPU assembly.

Table 6-5. Printer

Symptom	Cause	Corrective Action
Paper doesn't move; printer error message displayed `Check paper supply.`	Paper out or jammed.	Replace paper or clear paper jam.
	Defective motor/sensor cable assembly.	Replace motor/sensor cable assembly.
	Defective motor assembly.	Replace motor assembly.
	Defective motor drive assembly.	Replace CPU assembly.
	Defective roller.	Replace printer door assembly.
Paper moves then stops and displays an error message. `Check paper supply.`	Paper loaded incorrectly.	Make sure cardiograph is loaded properly with approved thermal paper.
	Dirty sensor lens.	Clean sensor lens.
	Defective sensor.	Replace sensor assembly.
	Defective motor/sensor cable assembly.	Replace motor/sensor cable assembly.
	Defective sensor circuit.	Replace CPU assembly.
	Defective roller.	Replace printer door assembly.
Paper stops in the wrong place after pressing (Page Advance) or (Auto). No error message.	Wrong type of paper.	Make sure cardiograph is loaded properly with approved thermal paper.
	Dirty sensor lens.	Clean sensor lens.
	Defective sensor.	Replace sensor assembly.
	Defective motor/sensor cable assembly.	Replace motor/sensor cable assembly.
	Defective sensor circuit.	Replace CPU assembly.
Wavy diagonal lines in printer self-test or distortion of printouts in the time axis.	Improper meshing of gears in motor assembly or door assembly.	Replace motor or door assembly.
Message: `Printer door open.`	Door is ajar.	Close door.
	Printhead bail or leaf spring touching contact post.	Check leaf spring behind printhead and contact post.
	Defective sensor assembly.	Replace sensor assembly.
	Defective motor/sensor cable assembly.	Replace motor/sensor cable assembly.
	Defective door-detect circuit.	Replace CPU assembly.

Table 6-5. Printer (continued)

Symptom	Cause	Corrective Action
Paper moves but nothing prints.	Paper loaded incorrectly, or non-approved or non-thermal paper installed.	Make sure cardiograph is properly loaded with approved thermal paper.
Printer moves but printing is faint.	Door improperly latched.	Check door latch.
	Paper loaded incorrectly, or non-approved or non-thermal paper installed.	Make sure cardiograph is properly loaded with approved thermal paper.
	Insufficient leaf spring tension or printhead out of position.	Check leaf spring for printhead platen pressure, door latch. Check for proper paper.
	Defective printhead or printhead cables.	Replace printhead assembly.
	Defective component in printer circuitry.	Replace CPU assembly.
	Selector S1 on CPU set incorrectly.	Set selector S1 correctly (refer to Chapter 7).
Printed data is garbled.	Defective printhead.	Replace printhead assembly.
	Defective component in data path.	1. Check printhead cables. 2. Replace CPU assembly.
Poor print quality or some dots not printing.	Dirty printhead.	Clean printhead.
	Loose ESD brush fibers.	Remove loose brush fibers and clean printhead.
	Incorrect printhead or sensor cable dress.	Correct cable dress so that printhead assembly moves properly.
	Defective printhead or printhead cables.	Replace printhead assembly.
	Defective component in printer circuitry.	Replace CPU assembly.
Some dots always on.	Defective printhead.	Replace printhead assembly.
Printing is dark on one side of page but faint on the other side.	Printhead is not free to float and provide even (uniform) pressure distribution across platen roller.	Correct binding condition. Replace printer door. Replace printhead assembly.

Table 6-6. Disk Drive (M1700A and M1701A only)

Symptom	Cause	Corrective Action
Disk drive inoperative.	Power problems.	Check power supply. Check disk drive power cable and plugs.
Error message `Try new disk` appears.	Defective cables, plugs.	Check cables, plugs.
	Defective disk.	Try known good disk.
	Defective drive.	Replace.
	Hardware problems on CPU assembly.	Replace CPU assembly.
	Unit is jarred while storing to disk.	Do not move unit during disk operations (while yellow disk drive light is on).
Fails Extended Self-test disk drive test.	Defective disk used for test.	Replace disk and retry.
	No disk in drive.	Insert disk in drive and retry.
	Disk write protected.	Change write protection on disk.
	Wrong disk density.	Use 1.44 MB disk.
	Defective cable.	Replace cable and retry.
	Defective disk drive.	Replace disk drive.
	Defective CPU assembly.	Replace CPU assembly.

Note

Follow these rules to keep your flexible disks and their stored files in good condition.

- **Never** manually open the silver shutter on the disk.
- **Do not** expose the disk to direct sunlight, extremes of temperature or humidity, magnetic fields, or dust.
- Place the disk in a protective cover when the disk is not inside the drive.
- Store disks in a clean, dry place.
- Clean the disk drive with a wet-dry cleaning kit regularly. Wet-dry cleaning kits are available from local computer stores.

  Clean the disk drive every six months unless the working environment is particularly dusty or dirty. Clean the drive more often in dusty or dirty environments.

  TraceMaster ECG Management System users:

  If you transfer ECGs to the TraceMaster System by disk, clean the TraceMaster drive every six months unless the working environment is particularly dusty or dirty. Clean the drive more often in dusty or dirty environments.
- Replace disks regularly. The recommended replacement interval is every three months. If the disks are used for more than 50 ECGs per day, replace the disks more frequently.
- For best results, use only Hewlet-Packard recommended disks. (HP part number M1700-89004)
- For more information, contact your Hewlett-Packard service representative.

Table 6-7. Preview Display and Logic (M1700A)

Symptom	Cause	Corrective Action
Washed out display.	Improper brightness or contrast adjustment or both.	Adjust brightness and contrast controls for best display appearance.
All white screen, backlights on.	Contrast or brightness or both misadjusted.	Adjust contrast or brightness or both.
	Interconnect cable between preview logic and display unplugged or defective.	Check that plug is fully connected. Replace cable if defective.
	Defective preview logic board.	Replace board.
	Defective preview power supply board.	Replace board.
	Defective LCD module.	Replace LCD module.
	Missing supply voltages to power supply and LCD module.	Verify presence of VCC and VIN at input to power supply board. Refer to Appendix A for pin assignments.
		Verify presence of VCC, VLCD, VCFL at power supply board output.
No brightness adjust.	Defective brightness potentiometer or defective power supply board.	Replace power supply board.
No contrast adjust.	Defective contrast potentiometer or defective power supply board.	Replace power supply board.
All black screen.	Contrast or brightness misadjusted.	Adjust contrast.
	Defective preview logic board.	Replace board.
	Defective LCD module.	Replace display assembly.
	Defective CPU assembly.	Replace CPU assembly.
All blue screen.	Defective preview logic board.	Replace board.
	Defective preview power supply board.	Replace board.
Screen is blank.	M1701A software loaded on an M1700A.	Load correct software.

Table 6-7. Preview Display and Logic (M1700A) (continued)

Symptom	Cause	Corrective Action
Backlight flickers. Half screen lit. No backlight but characters present.	Brightness misadjusted.	Adjust brightness knob for proper brightness level.
	Bad connection at preview power supply board J1.	Check that backlight cable is securely connected.
	Burned out or weak backlight bulb(s).	Replace LCD module.
	Defective power supply board.	Replace board.
Garbled data on display.	Interconnect cable between preview logic and display unplugged or defective.	Ensure that plug is fully connected. Replace cable if defective.
	Defective preview logic board.	Replace board.
	Defective CPU assembly.	Replace CPU assembly.

Table 6-8. Keyboard and Keyboard Display (LCD)

Symptom	Cause	Corrective Action
Display stays blank.	Contrast or brightness misadjusted.	Adjust contrast or brightness.
	No +5 volts due to defective interconnect cable.	Replace cable assembly.
		Test power supply.
	Defective LCD assembly	Replace user interface assembly.
	Defective 5 volt regulator in main power supply.	Replace CPU assembly.
Keys won't work. Unable to enter data or operate controls.	Interconnect cable unplugged or defective.	Reconnect or replace cable.
	Keyboard circuit board defective.	Replace user interface assembly.
	CPU assembly defective.	Replace CPU assembly.

Table 6-9. Transmit and Modem

Symptom	Cause	Corrective Action
Message: `Data transmission abnormal termination.`	Error 1540	See "Errors" earlier in this chapter.
	Error 1541	See "Errors" earlier in this chapter.
Message: `ERROR 153x: Remote site failure.`	Covers errors 1532, 1533, 1534, 1536, and 1537. The remote site is terminating the link and has sent the message to inform the local user.	None
Message: `No answer at site.`	Cabling problems between modem and cardiograph.	Perform Extended Self-test modem test.
	Telephone line or telephone cable defective.	Substitute normal telephone for modem and dial number. Ensure that modem answers with high-pitched tone.
Extended Self-test modem test failure	RS-232 cable not plugged in or defective.	Plug in to cardiograph; if defective, replace.
	Power cable not plugged in or defective, or cardiograph AC off.	Plug in to cardiograph and turn on AC; if defective, replace.
	Modem not turned on.	Turn on modem. If modem is turned on, or if unit is a fax modem, check for unplugged or defective power cable.
	Defective modem.	Replace modem.
	Defective CPU assembly.	Replace CPU assembly.
Unable to transmit or receive. Modem passes Extended Self-test.	Phone cable unplugged or defective.	Plug in phone cable; if defective, replace.
	Defective modem.	Replace modem.
	Defective CPU assembly.	Replace CPU assembly.

Testing the Power Supply

Use this procedure to check the voltages produced by the power supply. The cardiograph must be connected to AC power to test all the power supply voltages. All the voltage measurements are taken with respect to ground. Refer to Figure 6-3 for voltage test point locations.

Warning

When the cardiograph is connected to AC power, there are dangerous voltages on the line module terminals, even when the AC switch is off. When the AC switch is on, there are also dangerous voltages on the terminals of the mains transformer. If you must have the AC power connected while the cardiograph is open, do not touch any of the exposed connectors.

The rectifier assembly capacitors store hazardous amounts of energy during AC and battery operation. Be careful not to touch any of the exposed capacitor connections.

1. Open the top cover assembly as described in Chapter 7, "Removal and Replacement."
2. Make sure the cardiograph is connected to AC and that the AC switch is on. Then pull out the battery enough to disconnect it.

Caution

Be very careful to not short VIN to ground or to other pins. This will result in cardiograph failure.

3. Measure VIN. It should read approximately 24 V DC. The presence of this voltage confirms the proper operation of the mains transformer and the rectifier assembly under light load.
4. Measure VBAT+. It should read approximately 21 to 22 volts. This voltage confirms the proper operation of the battery charger.
5. Measure VBACK through the opening in the shield at the tab on transistor Q5 (see Figure 6-3). It should read +5 V DC. Its presence confirms the proper operation of the backup 5 volt supply.

Note

The battery voltage can be read on the keyboard display using the following sequence, starting from Standby:

a. Press the [On-Standby] key (to turn on the cardiograph).

b. Immediately press and hold the [Alt] key.

c. Press the [V] key (for "Voltage").

d. Release the [Alt] and [V] keys simultaneously.

The battery voltage will be displayed briefly in the center of the keyboard display. The battery voltage should be slightly higher when the cardiograph is operating on AC (AC LED is on), indicating that the battery is charging.

6. Install the battery and turn off the AC switch.
7. Measure VBAT+ again. If the battery is fully charged, the voltage should measure 19 to 20 volts.
8. Press the [On-Standby] switch to turn the cardiograph **On**.
9. Measure +5V. It should read +5 V DC. Its presence confirms the proper operation of the +5 volt supply.
10. Measure VFE at pin 5 of the ECG Input connector, J9. It should read approximately 11 volts. Its presence confirms the proper operation of the VFE regulator circuit that supplies power to the patient module.
11. Measure VPRINT. It should read approximately the same as VBAT+. Its presence confirms the proper operation of the printer switch circuit.
12. Measure VMOTOR. It should measure 15.6 to 17.9 V DC. Its presence confirms the proper operation of the regulator that supplies power to the motor.
13. Carefully measure VIN (see the CAUTION at step 3). VIN should read approximately one volt less than VBAT+. Its presence confirms the proper operation of the battery switch circuit.
14. Turn on the AC switch.
15. Measure VBAT+. It should read between 19 and 22 volts for a fully charged battery.
16. Carefully measure VIN again. It should read between 17 and 31 V DC. This confirms the operation of the mains transformer and the rectifier assembly under full load.
17. Close the top cover assembly.

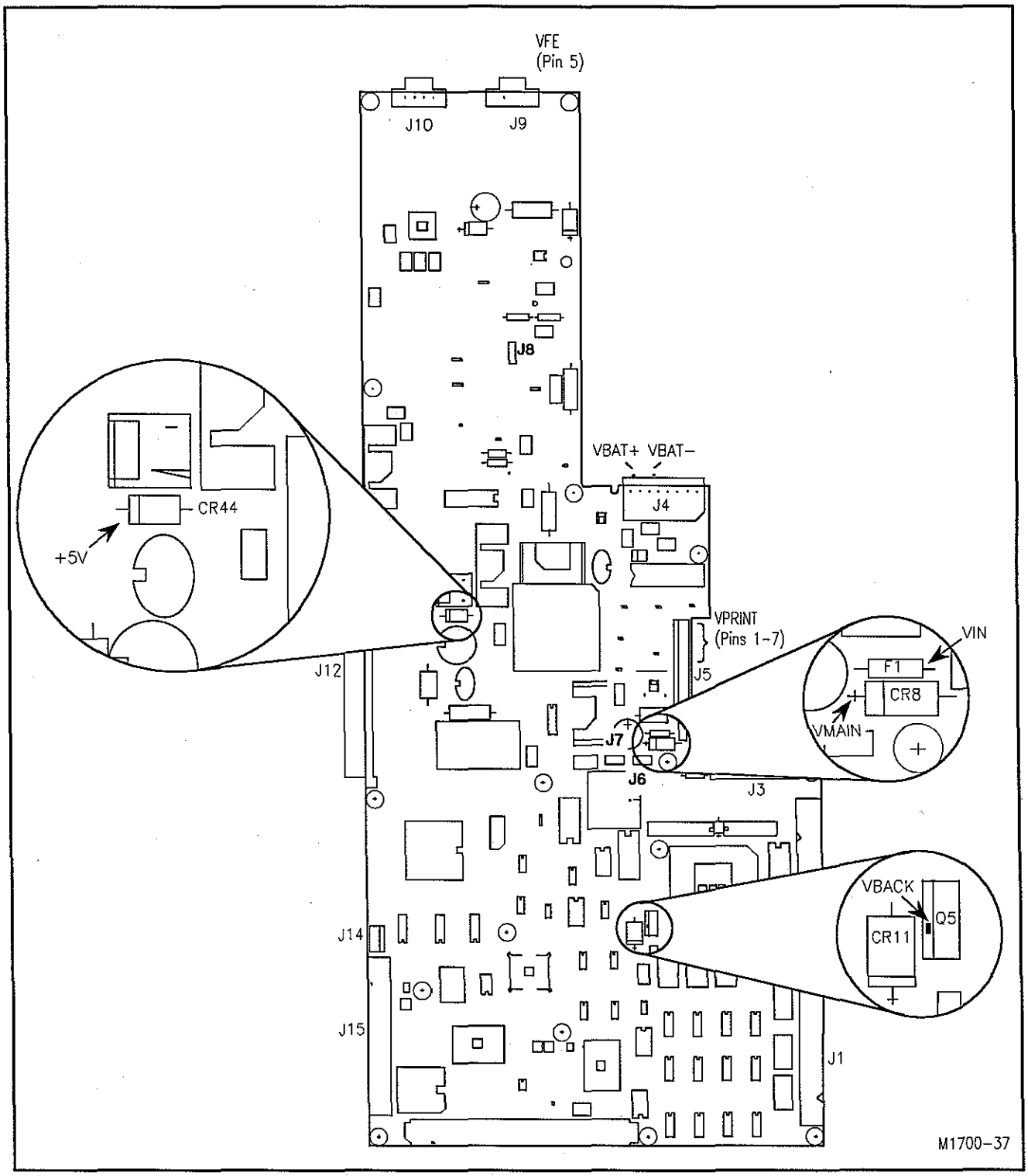


Figure 6-3. Voltage Test Locations.